PART 3

REPORTS OF MEETINGS OF COMMISSIONS

COMPTES RENDUS DES SÉANCES DES COMMISSIONS

COMMISSION 4: EPHEMERIDES (EPHEMERIDES)

Report of Meeting 25 August 1976

PRESIDENT: R. L. Duncombe SECRETARY: A. T. Sinclair

The Chairman asked for a moment of silence in memory of four members of the Commission who had died since the last IAU meeting: G. A. Chebotarev, G. M. Clemence, S. Herrick, and H. Hertz.

The Chairman announced the names recommended by the committee for the new officers of the Commission for the next three years:

President: V. K. Abalakin
Vice President: A. M. Sinzi
Organizing Committee: T. Lederle, J. H. Lieske, B. Morando, P. K. Seidelmann, G. A. Wilkins, and R. L. Duncombe

The meeting agreed that these names should be put to the Executive Committee.

The Chairman regretted that the report of the Commission had not been made available before the meeting, due to printing delays. He assured the meeting that all information communicated to him had been included in the report.

G. A. Wilkins gave a summary of the activities of the IAU working group on Numerical Data during the last three years. The main activity had been the organization of IAU Colloquium No. 35 held at Strasbourg the previous week. He felt that there was a need in Astronomy for a guide on the presentation of data, similar to a bulletin published by CODATA.

The Chairman announced a list of names of people who had been proposed as new members of the Commission: B. D. Yallop, G. M. R. Winkler, P. M. Janiczek, K. J. Johnston, and Y. T. Ting. The meeting agreed that their names should be put to the Executive Committee.

The Chairman drew the attention of the meeting to the following recommendation on the Physical Ephemeris of Mars.
"Considering that recent new determinations of the rotational elements of Mars indicate the need for a revision of the elements currently adopted in the physical ephemeris of Mars, and that a new approach to the definition of the origin of areographic longitudes appears useful (G. de Vaucouleurs, M. E. Davies and F. M. Sturms, Jr., J. Geophs. Res. 78, 4395, 1973), Commission 4 and 16 recommend

(1) that the tie between the new and current physical ephemeris of Mars be firmly established by appropriate comparisons between ground-based and Mariner coordinate systems, and
(2) that new elements and a new definition of the origin of the areographic longitudes consistent with the results of (1) above and the definitions adopted previously (IAU Trans XVB, 1973, 107) be incorporated in the physical ephemeris of Mars as soon as deemed practicable in the judgement of the cognizant Directors of the National Ephemerides Offices."

P. K. Seidelmann said that a similar resolution had been passed previously, and work was still underway to carry out that resolution.

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The Chairman said that the present resolution was to re-emphasize the need for this work.

The resolution was approved by the meeting.

The Chairman then introduced the following recommendation concerning cartographic coordinates and rotational elements of the planets and satellites.

"Noting that

(a) confusion exists regarding the present rotational elements of some of the planets

(b) extensive amounts of new data from radar observations and by direct imaging from spacecraft have made cartography of the surfaces of the Moon, Mercury, Venus and Mars a reality

(c) there will be an extension of these techniques to the mapping of larger satellites of Jupiter and Saturn in the near future

assert that

to avoid a proliferation of inconsistent cartographic and rotational systems, there is a need to define the rotational elements of the planets and satellites on a systematic basis and to relate the new cartographic coordinates rigorously to the rotational elements

and therefore recommend that

Commission 4 (Ephemerides) and Commission 16 (Physical Study of Planets and Satellites) establish a Joint Working Group to study the cartographic coordinates and rotational elements of the planets and satellites and to report recommendations thereon at the next general assembly of the IAU."

G. A. Wilkins questioned whether observers would in practice be prepared to change the systems they use at present. He quoted the fate of a recommendation made in 1884 that longitudes on the Earth should be measured positive towards the East.
The recommendation was approved by the meeting, with the understanding that the incoming and outgoing presidents of Commission 4 and 16 would arrange the membership of the Working Group.

P. K. Seidelmann spoke about plans to modify the layout and contents of the Astronomical Ephemeris and the American Ephemeris from 1981 onwards. Other publications would also be involved. The next publication of "Planetary Coordinates" would cover the years 1980-1984, and would be called "Planetary and Lunar Coordinates". It would give low precision planetary and lunar data, to be used for planning purposes, and also by those countries who wished to produce their own navigational almanacs. There would no longer be a distribution of the "advanced data" previously used for these purposes. However it was hoped that countries producing their own almanacs would make use of reproducible data provided by the U.S.A. and U.K. Nautical Almanac Offices. At present many countries use the "advanced data" to obtain information about astronomical phenomena for publication in diaries, calendars, etc. In future the publication "Astronomical Phenomena" will be expanded, and it is hoped that it can meet all these needs. The "Astronomical Ephemeris" and the "American Ephemeris" will be replaced by a single publication. The principal changes in the contents will be:

The hourly lunar ephemeris will be replaced by the coefficients of Chebyshev or economized polynomial series, which would represent

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the Moon's position for one day;

Differences would be eliminated throughout the volume;

Satellite data would be expanded to cover all natural satellites;

More stellar data would be included;

An ephemeris of the barycentre of the Solar System would be included for use in pulsar observation reductions;

The volume would be re-organized in a more logical manner. These new arrangements would be introduced in 1981, but the basis of the ephemerides would still be the same as at present. However from 1984 onwards it was hoped that the ephemerides would be on a new, improved basis, and the star positions would be based on FK5.

A description of the basis of the new ephemerides would be published so that other people could duplicate the computation of the ephemerides if they wished. The ephemerides would also be available on magnetic tape, to facilitate comparisions.

T. Lederle asked what sort of positions would be given in the star lists, and if Day Numbers would still be given.

P. K. Seidelmann replied that probably the mean position for the beginning of the year would be given, and Besselian Day Numbers, but not Independent Day Numbers.

G. A. Wilkins said that some thought had been given to the idea of giving star positions for the middle of the year in question. The Day Numbers would also be referred to the middle of the year, and so the volume would contain all the information necessary to compute apparent places for any time during the year. The present situation is that for the second half of the year the Day Numbers are referred to the beginning of the next year, and so next year's volume is needed to obtain the mean places of the stars. A. M. Sinzi pointed out that the middle of the year is used in the Japanese Ephemeris.

T. Van Flandern said that he had understood that a very precise means of computing apparent places was to be included in the new volume.

G. A. Wilkins replied that for each day the coefficients would be given of the matrix needed to apply precession and nutation from a fundamental fixed equator and equinox to the true equator and equinox of date. Aberration could be computed from the tabulations of the velocity of the Earth relative to the barycentre of the Solar System.

P. K. Seidelmann said that it was also planned to modify the form of the list of observatories given in the Ephemeris. It would be restricted to professional observatories, and an improved index would be given. At intervals a more detailed list would be given, including such information as the types and positions of the telescopes at the observatories.

V. K. Abalakin suggested that the geodetic datum to which an observatory's position was referred should be specified.

P. K. Seidelmann said that the form of the eclipse maps would be altered somewhat, to facilitate their production by a computer and graph plotter.

A. M. Sinzi commented that at Tokyo they already had a computer program to produce eclipse maps similar to those in the Ephemeris.

B. Morando gave a report on the work of the International Information Bureau on Astronomical Ephemerides, which had been created at the 1970 IAU General Assembly. Details of each set of data were included on a card, and these cards were sent to people who requested them. At present 158 names were on the mailing list, and 125 cards had been issued. The production of about a further 50 cards was in hand. The Bureau received a small grant from the IAU, but the bulk of its expenses was met by the Bureau des Longitudes. He announced that the present postal address of the Bureau was

B.I.I.E.A.
77 Avenue Denfert-Rochereau
75014-Paris
FRANCE

G. A. Wilkins questioned whether the issue of all of the cards to all of the users was the most efficient procedure. He suggested that the information could be given in the regular bulletins of the Stellar Data Centre, or the issue of cards could be restricted to sending only the relevant cards to people who requested information data of a particular type.

J. D. Mulholland said that he found the cards convenient to use, and he liked to have the complete set as it gave him information about data that he would not have expected to be available, and so would not have thought to ask about.

J. Kovalevsky reminded the meeting that it was necessary to renew the membership of the Bureau's advisory committee. He also proposed the following resolution.

> "Commission 4 recognizing the usefulness of the International Information Bureau on Astronomical Ephemerides (BIIEA) considers it important to continue its operation during the coming three years and requests the IAU to increase its subvention to this Bureau to $400 per year."

The proposal was seconded by R. L. Duncombe, and approved by the meeting. The Officers of Commission 4 then requested the following persons to serve on the Scientific Advisory Board of the International Information Bureau on Astronomical Ephemerides: T. Lederle, G. A. Wilkins, V. K. Abalakin, P. K. Seidelmann, and B. Morando, ex officio. A COSPAR representative will be appointed by that organization.

REPORT OF JOINT MEETING OF COMMISSIONS 4, 8, 31 ON THE NEW SYSTEM OF ASTRONOMICAL CONSTANTS

Report of Meeting 26 August 1976

PRESIDENT: R. L. Duncombe SECRETARIES: A. T. Sinclair, R. H. Tucker

The Joint Meeting of Commissions 4, 8, and 31 was called to consider and, if possible, to resolve the acceptance of the Report prepared by the Commission 4 Working Groups on Precession, Planetary Ephemerides, Units and Time Scales. The Chairman proposed to accept only questions of fact after each presentation on the agenda, and to delay general discussion until the whole report had been presented.

G. A. Wilkins described briefly the form of the new system of astronomical constants and related quantities; it follows the system adopted in 1964 with a few exceptions. It gives explicitly the

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relationships between the astronomical units of length, mass, and time, and units (metre, kilogram, and second) of the International System (SI). The choice of defining constants (arbitrary values), primary constants (best values from observations) and derived constants (calculated from the defining and primary constants) has been changed in a few cases. The astronomical unit of time (the day) is now based on the atomic second, rather than on the tropical year. Correspondingly, the new time-scale for use in apparent geocentric ephemerides is based on this unit and is offset from the scale of International Atomic Time (TAI) so that it will be continuous with the scale of ephemeris time for all practical purposes; it is defined precisely and unambiguously and it will be suitable for use with relativistic theories. The velocity of light (c) has a special significance since it is understood that its value will not be changed if the definition of the metre is changed; it would not be appropriate for astronomers to specify c as a defining constant since this would effectively redefine the metre. The system of constants is completed by adding constants for: the size, gravity field and shape of the Earth; the principal coefficients for precession and nutation; and the masses of the Moon and planets. Other coefficients and constants required for the reduction of celestial positions and the computation of ephemerides are given separately. A. H. Cook asked if the geodetic quantities were based on a mass for the Earth which included the atmosphere, and was told they were. He suggested that the point should be made more explicitly since the mass recommended by the IAG did not do so. R. d'E. Atkinson pointed out the need to correct the constant of aberration, as aberration was now to be computed using the Earth's velocity relative to the barycentre of the Solar System rather than the Sun. Wilkins agreed to consider this.

G. M. R. Winkler dealt with the problems and details of the new time scale proposed in the Report. It was emphasized that parts a and b provide the rate and epoch of a unique time scale for apparent geocentric ephemerides while part c provides for a family of dynamical time scales for equations of motion referred to the barycentre of the solar system and dependent upon the relativistic theory being used. The new dynamical time scale for apparent geocentric ephemerides is continuous with the present ephemeris time scale. The terminology and notation for the dynamical time scales will require further consideration. G. Becker raised the question of a name for the new time scale, and suggested "Astronomical Reference Time". G. M. R. Winkler said that no name had yet been decided, and meanwhile he thought it best to use the name "Dynamical Time Scale."

W. Fricke in a report on the activities of the Working Group on Precession presented the main arguments in favor of the adoption of a new value of the general precession. These arguments will be published in Astronomy and Astrophysics. In another paper the methods of determining lunisolar precession will be summarized and the observational material which was used in the determinations will be given. Fricke explained the reasons for the introduction of the new standard epoch and equinox 2000 and the use of the Julian century instead of the tropical century in the fundamental formulae for precession. Furthermore, he reported on the specification of the new fundamental reference system, the FK5, which will be compiled at Heidelberg.

T. Lederle reported on the proposed changes in the procedures for the computation of apparent places. The following modifications will be made simultaneously with the introduction of the new system of constants and the FK5: (a) the aberration terms which depend on the eccentricity of the Earth's orbit shall be shifted from the mean places to the reduction from mean to apparent places; (b) the nutation terms shall be slightly modified in such a way that the apparent places are more directly comparable with observations; (c) the reductions to apparent places shall be computed rigorously and directly from the mean places for the standard equinox.

In the course of his presentation he announced a revised wording for Recommendation 4(b) submitted by Atkinson and accepted by the Chairman on behalf of the Working Groups. T. Van Flandern proposed an addition to the notes, suggesting that there should be a possibility of making further amendments to the recommendations concerning nutation as a result of a Symposium on the subject to be held in Kiev in 1977.

J. H. Lieske discussed the expressions for the precession quantities. He stated that in comparing astronomical observations with calculated places of celestial objects, reductions have to be made to refer either the observed or the calculated positions to the same reference coordinate system. Such reductions include such well-known effects as aberration, parallax, precession and nutation. Although rather lengthy numerical expressions are usually given for the parameters describing precession, the expressions, in fact, only depend upon a rather limited set of basic parameters or fundamental constants and are thus amenable to revision. He examined the structure of the expressions usually employed in calculating the effects of precession and outlined the method by which the expressions are revised to account for changes in the fundamental astronomical constants. It was shown that the basic set of parameters, upon which the lengthy polynomials for calculating the mean obliquity of date and the elements of the precession matrix depend, consists of the mean obliquity and the speed of general precession in longitude at a fixed epoch E_C together with the system of planetary masses. Expressions for the precession quantities enabling one to precess to and from an arbitrary epoch were developed as a function of the fundamental astronomical constants. The expressions with numerical values of the coefficients are given relative to epoch J2000.0. They must be used with the introduction of the new constants into the ephemerides and in constructing the new fundamental reference system, the FK5. The developments presented are applicable for revising relevant precession quantities whenever the system of astronomical constants is changed.

P. K. Seidelmann discussed the numerical values of the astronomical constants proposed for adoption in the Report. The values, ranges of uncertainties, and sources of the specific values of Recommendation 1 on the IAU (1976) System of Astronomical Constants and of Recommendation 6 on other quantities for use in the preparation of the Ephemerides were presented. It was pointed out that the following quantities have not been specified: the value for the correction to the equator and equinox of the FK4; the secular acceleration of the Moon, i.e., the contribution to the mean longitude of the Moon due to tidal friction; and the rotational elements of the planets, i.e., the periods of rotation and the location of the poles of rotation.

The Chairman opened the Report to general discussion remarking that when the time came to vote for acceptance of the Report this would give formal approval to the Recommendations only, leaving the Notes for further revision by the signers of the Report in the light

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of comments received. S. Vasilevskis proposed an amendment to the wording of Recommendation 3(b), so that it should read "a correction to the motion of the equinox of the FK4 shall be derived from relevant modern observations." This was in view of a paper presented by K. C. Blackwell on equinox motion at a meeting of Commission 8. W. Fricke welcomed the change of wording, as it gave him more freedom in the compilation of FK5. P. J. Melchior remarked that the constant of nutation proposed in the Report was not consistent with the proposed constants and any model of the rigid body nutation of the Earth. W. Fricke thought that a new value for the constant could be considered at the Kiev Symposium, where the effect of non-rigidity would be discussed. C. A. Murray asked if the previous adherance to a rigid Earth model for nutation would be abandoned at the Kiev Symposium. P. J. Melchior commented that the present nutation constant did not conform to a rigid body model, and if there was sufficient agreement the Symposium may well recommend the inclusion of further non-rigid-body terms. D. Eckhardt remarked that the proposed set of constants for the gravity field of the Moon was over-determined. One of the constants could be derived from the others. J. G. Williams said that the recommended values were self consistent under the restriction imposed by Eckhardt's own theory. Y. Kozai questioned the value of 0.0167 for the J_2 coefficient of Saturn; he would prefer 0.016. It was thought that this could have been a typing error, and the Chairman assured the meeting that the final version of the Recommendations would be thoroughly checked. J. D. Mulholland remarked that the clear intention of the IAU in 1973 was to adopt the speed of light as a defining constant, which would be unchangeable. J. Terrien replied that the General Conference of Weights and Measures was expected to adopt this procedure eventually, but that they saw no urgency in the matter. Meanwhile he thought that the procedure adopted in the Report was the correct thing to do. P. Herget asked who would have the power to amend the Recommendations to this Report following the Kiev Symposium. The Chairman replied that this would be under the control of Commission 4. S. Aoki pointed out that the values given in the Report for the constants defining the size and gravity field of the Earth would soon be superseded. I. Mueller remarked that this was an unfortunate situation which could not be avoided. He remarked further that the revised wording of Recommendation 4(b) appeared to be in conflict with Woolard's use of the terms "axis of figure" and "axis of rotation." R. d'E. Atkinson said that he did not think there was any ambiguity, because the recommendation referred to the forced periodic terms in the motions of these axes. B. Guinot said that a convenient name was needed for the new axis, and suggested "mean diurnal axis". I. Mueller suggested that the name "Eulerian Pole of Rotation" was suitable. R. d'E Atkinson said that Woolard did not use this name explicitly in his work on nutation, but used the term "Eulerian place of the pole of rotation" in the caption to one of his diagrams. The Chairman suggested that the chairmen of the Working Groups should try to find a suitable name, and if they did it could be included in the Notes.

B. K. Bok, representing Commission 33, was invited to address the meeting. He expressed the great interest of astronomers of all disciplines in the matters being discussed and said that he had been well satisfied with the care and thoroughness with which the Report had been prepared. He hoped to see the FK5 published now, on a well defined system, as a good fundamental reference system was very important. He said Commission 33 hoped for a firm decision on this Report from this meeting.

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The Chairman then asked the meeting to vote for the acceptance of the Resolution contained in the Report, on the understanding that Recommendations 3(b) and 4(b) would be amended as discussed during the meeting, and all known errors would be corrected. The Resolution was proposed and seconded, and carried by general consent, with no objections.

JOINT REPORT OF THE WORKING GROUPS OF IAU COMMISSION 4 ON PRECESSION, PLANETARY EPHEMERIDES, UNITS AND TIME-SCALES

I. INTRODUCTION

The report contains recommendations for: the revision of the IAU System of Astronomical Constants that was adopted in 1964; the introduction of a new standard epoch; the improvement of the specification of the fundamental reference system and related computational procedures; time scales for dynamical theories and ephemerides; and the values of other data on the planets and satellites. These changes are intended to provide an agreed basis for a new fundamental catalogue (FK5) and for a new set of high-precision lunar and planetary ephemerides. The new catalogue and ephemerides are required in order to meet the greater demands on positional and dynamical astronomy being made by new techniques of observation, such as radar and laser ranging and long baseline radio interferometry, as well as by improvements in the classical techniques of astrometry. These studies should lead to advances in our understanding of the dynamics of the Earth and of the solar system, the theory of relativity, and both galactic and extragalactic astronomy. It is hoped that these recommendations will be adopted by all who are distributing ephemerides or observational data for general use. The recommendations in this report have been developed from the recommendations of IAU Colloquium No. 9, which was held at Heidelberg in August 1970 (Celestial Mechanics 4, 128-280, 1971). At the IAU General Assembly that followed immediately afterwards, Commission 4 set up three working groups, which included members of other Commissions having an interest in these matters (Trans. IAU XIVB, 81-83, 1971). The preliminary reports of the working groups (Trans. IAU XVA, 9-10, 1973) were discussed at the next General Assembly at Sydney in August 1973 at a Joint Discussion (Highlights of Astronomy 3, 209-232, 1974), and by Commission 4, which decided that the groups should continue their work (Trans. IAU XVB, 70, 1974). Members of the groups and some other astronomers met in Washington in October 1974 at a small discussion meeting arranged by the President of Commission 4. The recommendations of this meeting were considered further by the working groups and others, and provided the basis for this joint report. The chairmen of the three groups met at Herstmonceux at the beginning of October 1975 to prepare the draft of the report, which was circulated widely for comment. The authors met in Washington in June 1976 and prepared the revised report for submission to a Joint Meeting of Commissions 4, 8 and 31 to be held during the IAU Assembly at Grenoble in August 1976.

The new system of astronomical constants is intended to replace the system adopted at Hamburg in 1964. At that time it was recognized that the precessional constants and the planetary masses differed significantly from the most likely values, but it was considered that it would be desirable to continue to use the current values until new values could be introduced with greater confidence in a new fundamental catalogue and in ephemerides based on improved

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theories and new comparisons with observation. Whenever appropriate the values of the constants have been expressed in the units of the International System (SI).

The opportunity has been taken to introduce improved values of the constants for the Earth for dynamical purposes; the values given are the currently representative estimates of geodetic parameters as recommended by the International Association of Geodesy in 1975. No attempt has been made to introduce a full set of parameters to define a standard model for the Earth. Until such a model and a new theory of nutation can be adopted, consideration will be given to the possibility of applying correction terms determined from observations. A change in the value of the general precession in longitude has become necessary because of the introduction of new observational methods, such as the direct measurement of distances in the planetary system and long baseline radio interferometry. The error of about $1\overset{''}{.}1$ per century in the present value of the general precession and a spurious motion of the equinox of about the same size manifest themselves as unacceptable discordances between the observed and theoretical motions of celestial objects and introduce spurius contributions into the proper motions of stars.

The recommendations for the use of the Julian century, rather than the tropical century, which is both variable and theory dependent, and for the adoption of the new standard epoch and equinox of 2000 are intended to simplify precessional computations and to unify the standard epochs of the fundamental catalogue and planetary theories.

A dynamical time scale for apparent geocentric ephemerides is specified in such a way as to provide continuity with the current values and practice in the use of Ephemeris Time. It is based on the SI second as the unit of time and is distinct from the practical realization of International Atomic Time (TAI) which is only available from 1958 onward. It facilitates the comparison of observations with theories of all types.

The values given for the masses of the minor planets and satellites, and the other data on the Sun, Moon and planets are considered to be the current best estimates of these quantities and to provide a suitable basis for the construction of ephemerides except in those cases where the requirements for extreme accuracy are more important than the advantages of standardization. It is intended that these values will be used in the international ephemerides except where new information indicates that the value given here is significantly in error.

We regard it as essential that decisions on the matters discussed in this report be made at the IAU General Assembly in 1976 in order that the new constants and procedures can be used in the preparation of the new fundamental catalogue FK5 and new high-precision lunar and planetary ephemerides. We consider that the annual publications based on these new data should be issued for the year 1984 and we see no need for the publication of differential corrections for the preceding years. The individual recommendations are presented in section III of this report and notes on them are given in section IV. These notes are not intended to form part of the recommendations, but are given by way of explanation or justification.

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II. RESOLUTION

We request that the following draft resolution be submitted to the Joint Meeting of IAU Commissions 4, 8 and 31 with the view of its being adopted at the Sixteenth General Assembly of the IAU.

"The IAU endorses the recommendations given in the Joint Report of the Working Groups of Commission 4 on:

the IAU (1976) System of Astronomical Constants,
the new standard epoch and equinox,
the fundamental reference frame,
the procedures for the computation of apparent places and the reduction of observations,
time scales for dynamical theories and ephemerides,
and other quantities for use in the preparation of ephemerides;

and recommends that they shall be used in the preparation of the fundamental catalogue FK5 and of the national and international ephemerides for the years 1984 onwards, and in all other relevant astronomical work.

III. RECOMMENDATIONS TO IAU GENERAL ASSEMBLY, 1976

RECOMMENDATION 1: IAU (1976) SYSTEM OF ASTRONOMICAL CONSTANTS

It is recommended that the following list of constants shall be adopted as the "IAU (1976) System of Astronomical Constants".

Units

The units metre (m), kilogram (kg) and second(s) are the units of length, mass and time in the International System of Units (SI).

The astronomical unit of time is a time interval of one day ($\underline{D}$) of 86400 seconds. An interval of 36525 days is one Julian century.

The astronomical unit of mass is the mass of the Sun ($\underline{S}$).

The astronomical unit of length is that length ($\underline{A}$) for which the Gaussian gravitational constant ($\underline{k}$) takes the value 0.017 202 098 95 when the units of measurement are the astronomical units of length, mass and time. The dimensions of $\underline{k}^2$ are those of the constant of gravitation ($\underline{G}$), i.e., $L^3M^{-1}T^{-2}$. The term "unit distance" is also used for the length $\underline{A}$.

Defining constants

1.	Gaussian gravitational constant	$\underline{k}$ = 0.017 202 098 95

Primary constants

2.	Speed of light	$\underline{c}$ = 299 792 458 m s^{-1}
3.	Light-time for unit distance	τ_A = 499.004 782 s
4.	Equatorial radius for Earth	$\underline{a}_e$ = 6 378 140 m
5.	Dynamical form-factor for Earth	$\underline{J}_2$ = 0.001 082 63
6.	Geocentric gravitational constant	$\underline{GE}$ = 3.986 005 X $10^{14}m^3s^{-2}$
7.	Constant of gravitation	$\underline{G}$ = 6.672 X $10^{-11}m^3kg^{-1}s^{-2}$
8.	Ratio of mass of Moon to that of Earth	μ = 0.012 300 02
9.	General precession in longitude, per Julian century, at standard epoch 2000	$\underline{p}$ = 5 029″.096 6

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10.	Obliquity of the ecliptic, at standard epoch 2000	$\varepsilon = 23°26'\ 21''\!.448$
11.	Constant of nutation, at standard epoch 2000	$\underline{N} = 9''\!.2109$

Derived constants

12.	Unit Distance	$\underline{c}\,\tau_A = \underline{A} = 1.495\ 978\ 70 \times 10^{11}\,\mathrm{m}$
13.	Solar parallax	$\arcsin(\underline{a}_e/\underline{A}) = \pi_\odot = 8''\!.794\ 148$
14.	Constant of aberration, for standard epoch 2000	$\kappa = 20''\!.495\ 52$
15.	Flattening factor for the Earth	$\underline{f} = 0.003\ 352\ 81 = 1/298.257$
16.	Heliocentric gravitational constant	$\underline{A}^3\underline{k}^2/\underline{D}^2 = \underline{GS} = 1.327\ 124\ 38 \times 10^{20}\,\mathrm{m}^3\mathrm{s}^{-2}$
17.	Ratio of mass of Sun to that of Earth	$(\underline{GS})/(\underline{GE}) = \underline{S}/\underline{E} = 332\ 946.0$
18.	Ratio of mass of Sun to that of Earth+Moon	$(\underline{S}/\underline{E})/(1+\mu) = 328\ 900.5$
19.	Mass of the Sun	$(\underline{GS})/\underline{G} = \underline{S} = 1.989\ 1 \times 10^{30}\ \mathrm{kg}$

System of planetary masses

20. Ratios of mass of Sun to those of the planets and their satellites

Mercury	6 023 600	Jupiter	1 047.355
Venus	408 523.5	Saturn	3 498.5
Earth+Moon	328 900.5	Uranus	22 869
Mars	3 098 710	Neptune	19 314
		Pluto	3 000 000

RECOMMENDATION 2: THE NEW STANDARD EPOCH AND EQUINOX
It is recommended that:

(a) the new standard epoch (designated J2000.0) shall be 2000 January 1$^{\mathrm{d}}$5, which is JD 2 451 545.0, and the new standard equinox shall correspond to this instant;

(b) the unit of time for use in the fundamental formulae for precession shall be the Julian century of 36525 days; and

(c) the epochs for the beginning of year shall differ from the standard epoch by multiples of the Julian year of 365.25 days.

RECOMMENDATION 3: THE FUNDAMENTAL REFERENCE FRAME

It is recommended that:

(a) the fundamental reference frame defined by the positions and centennial variations in the FK5 shall correspond as closely as possible to the dynamical reference frame;

(b) a correction to the zero point of right ascensions of the FK4 (equinox correction) and a correction to the motion of the equinox of the FK4 shall be derived from relevant modern observations;

(c) the expression for Greenwich mean sidereal time at 0$^{\mathrm{h}}$UT shall be amended by the same equinox correction and motion as adopted for the FK5 in order to avoid a discontinuity in UT.

RECOMMENDATION 4: THE PROCEDURES FOR THE COMPUTATION OF APPARENT PLACES AND THE REDUCTION OF OBSERVATIONS

It is recommended that:

(a) stellar aberration shall be computed from the total velocity of the Earth referred to the barycentre of the Solar System, and mean places shall not contain E-terms;

(b) the tabular nutation shall include the forced periodic terms listed by Woolard for the axis of figure in place of those given for the instantaneous axis of rotation, and the two calibrations performed by him shall be revised accordingly, taking account of the change in the adopted precession;

(c) reductions to apparent place should be computed rigorously and directly, without the intermediary of the mean place for the beginning of year, whenever high-precision is required.

RECOMMENDATION 5: TIME-SCALES FOR DYNAMICAL THEORIES AND EPHEMERIDES

It is recommended that:

(a) at the instant 1977 January $01^d00^h00^m00^s$TAI, the value of the new time-scale for apparent geocentric ephemerides be 1977 January $1^d.000\,372\,5$ exactly;

(b) the unit of this time-scale be a day of 86400 SI seconds at mean sea level;

(c) the time-scales for equations of motion referred to the barycentre of the solar system be such that there be only periodic variations between these time-scales and that for the apparent geocentric ephemerides; and

(d) no time-step be introduced in International Atomic Time.

RECOMMENDATION 6: OTHER QUANTITIES FOR USE IN THE PREPARATION OF EPHEMERIDES

It is recommended that the values given in the following list should normally be used in the preparation of new ephemerides.

1. Masses of minor planets

Minor Planet	Mass in solar mass
(1) Ceres	5.9×10^{-10}
(2) Pallas	1.1×10^{-10}
(4) Vesta	1.2×10^{-10}

2. Masses of satellites

Planet	Satellite	Satellite/ Planet mass
Jupiter	Io	4.70×10^{-5}
	Europa	2.56×10^{-5}
	Ganymede	7.84×10^{-5}
	Callisto	5.6×10^{-5}
Saturn	Titan	2.41×10^{-4}
Neptune	Triton	2×10^{-3}

3. Equatorial radii in km

Mercury	2 439	Jupiter	71 398	Moon	1 738
Venus	6 052	Saturn	60 000	Sun	696 000
Earth	6 378.140	Uranus	25 400		
Mars	3 397.2	Neptune	24 300		
		Pluto	2 500		

4. Gravity fields of the planets

	J_2	J_3	J_4
Earth	+0.001 082 63	-0.254×10^{-5}	-0.161×10^{-5}
Mars	+0.001 964	+0.000 036	
Jupiter	+0.014 75		-0.000 58
Saturn	+0.016 45		-0.001 0
Uranus	+0.012		
Neptune	+0.004		

	C_{22}	S_{22}	S_{31}
Mars	-0.000 055	+0.000 031	+0.000 026

5. Gravity field of the Moon

$\gamma = (B-A)/C = 0.000\,227\,8$ $\qquad C/MR^2 = 0.392$

$\beta = (C-A)/B = 0.000\,631\,3$ $\qquad I = 5\,552''.7 = 1^\circ\,32'\,32''.7$

$C_{20} = -0.000\,202\,7$ $\qquad C_{30} = -0.000\,006$ $\qquad C_{32} = +0.000\,004\,8$

$C_{22} = +0.000\,022\,3$ $\qquad C_{31} = +0.000\,029$ $\qquad S_{32} = +0.000\,001\,7$

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$S_{31} = +0.000\ 004$

$C_{33} = +0.000\ 001\ 8$
$S_{33} = -0.000\ 001$

IV. NOTES ON RECOMMENDATIONS

NOTES ON RECOMMENDATION 1

Units

The constants of this revised system are generally expressed in terms of the SI units in order to ensure compatibility with the usage in related sciences. In astronomy it is, however, necessary to use the astronomical system of units of length, mass and time. The astronomical unit of time (day) is redefined in terms of the SI second, which was itself defined so as to be equal to the ephemeris second to within the error of the determination. Specifically it is the SI second at mean sea level.

1. The Gaussian gravitational constant serves to define the astronomical unit of length when the corresponding astronomical units of time and mass are already defined. The value for *k* is that adopted by the IAU in 1938. The value (rounded) of $k/86400$ is $1.990\ 983\ 675 \times 10^{-7}$.

2. The value for the speed of light is that recommended by the fifteenth General Conference on Weights and Measures in 1975. It is understood that this value will be unchanged even if the metre is redefined in terms of a different wave-length from that now used.

3. The value of the light-time for unit distance (1 astronomical unit of length) is based on radar measurements of planetary distances. It is numerically equal to the number of light-seconds in 1 astronomical unit of length. Its reciprocal (0.002 003 988 81) is equal to the speed of light in astronomical units of length per second. The speed of light in astronomical units per day is 173.144 633.

4. The term "equatorial radius for Earth" refers to the equatorial radius of an ellipsoid of revolution that approximates to the geoid. (See also note 15.) The values given for constants 4, 5, 6 and 15 are those recommended by the International Association of Geodesy at Grenoble in 1975 as currently representative estimates of fundamental geodetic parameters.

5. The term "dynamical form-factor for Earth" refers to the coefficient of the second zonal harmonic in the expression for the Earth's gravitational potential as defined in Trans. IAU XIIB (1964), 117-8, 1966. (See also notes 4 and 15.)

6. The geocentric gravitational constant is appropriate for use for geocentric orbits when the units are the metre and the second; *E* denotes the mass of the Earth including its atmosphere. (See also note 4.)

7. The value for the constant of gravitation is that given in the CODATA system of physical constants of 1973 (CODATA Bull. No. 11).

8. The value for the mass ratio is based on recent data from lunar and planetary spacecraft. (Reference as Note 3.) The mass of the

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Earth includes the atmosphere. The reciprocal of 0.012 300 02 is 81.3007.

9. The value of the general precession in longitude has been derived on the basis of recent determinations of the correction to Newcomb's value of the lunisolar precession (Ref: Fricke, W., 1967 Astron. J. 72, 1368; 1971 Astron. & Astrophys. 13, 298) and on the basis of a new value of the planetary precession derived from the new planetary masses. For convenience of those making differential corrections the exact value $\Delta p_1 = +1''.10$ has been adopted in computing the new value of p for 2000. The four decimal places of p are required in order to secure consistency with computations based on the current value for 1900 and the correction Δp_1. A corresponding set of numerical formulae for precessional reductions will be made available. (Ref: Lieske, J., in press.)

10. The value of the obliquity of the ecliptic results from applying secular terms computed with the new values of the planetary masses to the current value for 1900. (Ref: Lieske, J., in press.)

11. The value of the constant of nutation results from applying the secular term given by Woolard (Astron. Papers American Ephemeris 15, 153, 1961) to the current value for 1900. The value will have to be changed as soon as it is possible to adopt a new theory of nutation based on a non rigid model of the Earth. In consideration of the symposium on nutation to be held in Kiev in 1977, it was agreed at Grenoble that the adopted recommendations concerning nutation may be amended by Commission 4.

12.-19. The values of the derived constants have been computed from the values of the defining and primary constants. All the values are consistent with those determined more directly from observations.

12. The number of metres in one astronomical unit of length is now treated as a derived constant.

13. The rounded value $8''.794$ for the solar parallax may be used except where extra figures are required to ensure numerical consistency.

14. The constant of aberration is the ratio of the mean speed of the Earth to the speed of light, and is conventionally expressed in seconds of arc. It is calculated in radians from the expression $F\,k\tau_A/86400$ where F is the ratio of the mean speed of the Earth to the speed of a hypothetical planet of negligible mass moving around the Sun in a circular orbit of unit radius. The value of F for epoch 2000 is 1.000 1414, and is given by

$$F\,k = n\,a\,(1-e^2)^{-\frac{1}{2}}$$

where n is the sidereal mean motion of the Sun in radians per day, a is the perturbed mean distance of the Sun in astronomical units of length, and e is the mean eccentricity of the Earth's orbit.

The rounded value $20''.496$ may be used for κ except where the extra figures are required to achieve numerical consistency.

15. The flattening factor for the Earth is derived from the adopted values of the primary geodetic parameters using the condition that the corresponding ellipsoid of revolution shall be an equipotential surface. (See Note 4.) (Ref: Geodetic Reference System 1967, IAG Spec. Pub. No. 3, 1971)

16. The heliocentric gravitational constant is appropriate for use for heliocentric orbits when the units are the metre and the second.

17.-20. The values given for the reciprocal masses of the planets include the contributions from atmospheres and satellites. For Mercury, Venus and Mars values close to the best spacecraft determinations are adopted. For the Earth the mass is that derived from the adopted values of A, GE and μ. For Jupiter, Uranus and Neptune the modern determinations do not indicate the necessity to change the Newcomb values. The value for Saturn is the unweighted mean of the most reliable determinations. The value for Pluto is based on analyses of the motion of Neptune.

(Ref: Howard H. T., et al, Science 185, 12 July 1974; Anderson, J., Trans AGU 55, May 1975; Duncombe, R. L., et al, Highlights of Astronomy 3, 1973.)

The values given for the reciprocal masses are to be treated as exact, except that for Earth+Moon the gravitational constant should be calculated from GE(1+μ), that is from the exact values of the primary constants, if numerical consistency is required.

The mass of the Sun in kilograms is given to indicate the relationship between the astronomical and SI units of mass; it is known only to the low precision with which the constant of gravitation is known in SI units. The corresponding values of the masses of the planets are:

Mercury	$3.302\,2 \times 10^{23}$ kg	Jupiter	$1.899\,2 \times 10^{27}$ kg
Venus	$4.869\,0 \times 10^{24}$ kg	Saturn	$5.685\,6 \times 10^{26}$ kg
Earth	$5.974\,2 \times 10^{24}$ kg	Uranus	$8.697\,8 \times 10^{25}$ kg
Moon	$7.348\,3 \times 10^{22}$ kg	Neptune	$1.029\,9 \times 10^{26}$ kg
Mars	$6.419\,1 \times 10^{23}$ kg	Pluto	7×10^{23} kg

Ranges of uncertainty for the constants

The true values of the primary constants are believed to lie between the following limits:

c:	299792456.8 - 299792459.2	G:	$(6.668 - 6.676) \times 10^{-11}$
τ_A:	499.004 776 - 499.004 788	μ:	0.012 300 06 - 0.012 299 97
a_e:	6 378 135 - 6 378 145	p:	5028.95 - 5029.25
J_2:	0.001 082 62 - 0.001 082 64	ε:	23°26'21".35 to ... 21".55
GE:	$(3.986002 - 3.986\,008) \times 10^{14}$	N:	9".200 - 9".211

Correspondingly, the limits for the derived constants are:

A :	$(1.495\,978\,68 - 1.495\,978\,72) \times 10^{11}$
$\pi_\odot$:	8".794 141 - 8".794 155
κ :	20".495 518 - 20".495 520
f :	0.003 352 79 - 0.003 352 83
GS :	$(1.327\,124\,33 - 1.327\,124\,43) \times 10^{20}$
S/E:	332 945.7 - 332 946.3
S :	$(1.9879 - 1.9903) \times 10^{30}$

The limits for the reciprocal masses of the planets are believed to be:

Mercury:	6 020 000 - 6 027 000	Jupiter:	1 047.330 - 1 047.380
Venus :	408 521 - 408 526	Saturn :	3 497 - 3 500

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Earth + Moon:	328 900.0 - 328 901 .0	Uranus :	22 650 - 23 100
Mars :	3 098 600 - 3 098 760	Neptune:	19 300 - 19 450
		Pluto :	2 000 000 - 15 000 000

NOTES ON RECOMMENDATION 2

1. The new standard epoch is one Julian century after 1900 January $0^{d}.5$, which corresponds to the fundamental epoch of Newcomb's planetary theories. The new standard epoch is expressed in terms of dynamical time instead of Universal Time. Specifically for precise planetary and lunar theories, it is expressed in terms of the time scale of the equations of motion with respect to the barycentre of the Solar System.

2. In the new system a Julian epoch is given by

J2000.0 + (JD - 2 451 545.0)/365.25,

where JD symbolizes the Julian date. If the Besselian epoch is still required, it is given by

B1900.0 + (JD - 2 415 020.313 52)/365.242 198 781.

The Besselian year is here fixed at the length of the tropical year ($365^{d}.242$ 198 781) at B1900.0 (JD 2 415 020.313 52).

The prefixes J and B are used to distinguish Julian and Besselian epochs; they may be omitted only where the context, or precision, makes them superfluous.

NOTES ON RECOMMENDATION 3

1. Failure to distinguish between the catalogue equinox of the FK4 (that is its zero point of right ascension on the equator) and the dynamical equinox (the crossing point of the ecliptic on the equator) has been the cause of much difficulty. The FK4 equinox was based on determinations of the dynamical equinox before 1930.

Recent determinations of the equinox corrections have to be taken into account in the determination of the system of the FK5 such that the equinox error will be removed as far as currently possible together with the removal of an erroneous motion of the equinox of the FK4. The corrections to equinox motion and precession must be applied together to avoid introducing an additional fictitious rotation into the stellar proper motions in right ascension.

2. The current expression for Greenwich mean sidereal time is given in the <u>Explanatory Supplement to the Astronomical Ephemeris</u> on page 75.

NOTES ON RECOMMENDATION 4

1. The elliptic component in the Earth's velocity has traditionally been omitted in the computation of the day numbers, and the so-called E-terms of aberration have remained imbedded in the mean places of celestial objects. This practice has caused much confusion and it is convenient to use the occasion of other changes to remove E-terms from mean places and to include them in the reduction from mean to apparent place so that the apparent places will not be changed. The mean places in the FK5 will not contain E-terms and so tables will be given in the FK5 for reducing mean places with E-terms included (for example, mean places in the N30 catalogue) to mean places without E-terms.

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2. Nutation is taken into account in the current procedure for computing true places by a reduction from the mean celestial pole of date to a celestial pole which approximates to the direction of the instantaneous axis of rotation of the Earth. It has, however, been demonstrated that observations give the place of a pole whose position with respect to the mean pole of date can be obtained by the procedure described in Recommendation 4 (b). This pole may continue to be called the true celestial pole of date. The prescribed procedure may be achieved by removing the seven small forced periodic-terms in Woolard's equations 55 (Astron. Papers American Ephemeris 15, 133, 1953), by substituting the corresponding terms in equations 54 (page 132), and by scaling.

The equation of the equinoxes (nutation in right ascension on the equator) causes periodic variations in the location of the true equinox of date and hence a variation in apparent sidereal time. In certain applications it may be convenient to remove the effects of these periodic variations by subtracting the equation of the equinoxes, but the origin of apparent right ascension shall continue to be the true equinox of date.

3. It is intended that formulae and tabulations will be made available for use in rigorous, direct reductions without the intermediate formation of the mean place for the beginning of the year. For users who do not require the highest precision, Besselian day numbers will still be provided.

NOTES ON RECOMMENDATION 5

1. The time-like arguments of dynamical theories and ephemerides are referred to as dynamical time-scales. While it is possible, and desirable to base the unit of a dynamical time-scale on the SI second (which is used in the draft IAU (1976) system of astronomical constants), it is necessary to recognize that in relativistic theories there will be periodic variations between the unit of time for an apparent geocentric ephemeris and the unit of the corresponding time-scale of the equations of motion, which may, for example, be referred to the centre of mass of the Solar System. (In the terminology of the theory of general relativity such time-scales may be considered to be proper time and coordinate time, respectively.) The time-scales for an apparent geocentric ephemeris and for the equations of motion will be related by a transformation that depends on the system being modelled and on the theory being used. The arbitrary constants in the transformation can be chosen so that the time-scales have only periodic variations with respect to each other. Thus, it is sufficient to specify the basis of a unique time-scale to be used for new, precise, apparent geocentric ephemerides.

The dynamical time scale for apparent geocentric ephemerides of Recommendation 5(a) and (b) is a unique time-scale independent of theories, while the dynamical time-scales referred to the barycentre of the Solar System are a family of time-scales resulting from the transformations of various theories and metrics of relativistic theories.

2. This recommendation specifies a particular dynamical time-scale for apparent geocentric ephemerides that is effectively equal to TAI + $32^{\mathrm{s}}.184$. (There are formal differences arising from random and, possibly, systematic errors in the length of the TAI second

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and the method of forming TAI, but the accumulated effect of such errors is likely to be insignificant for astronomical purposes over long periods of time.) The scale is specified with respect to TAI in order to take advantage of the direct availability of UTC (which is based on the SI second and is simply related to TAI), and to provide continuity with the current values and practice in the use of Ephemeris Time. Continuity is achieved since the chosen offset between the new scale and TAI is the current estimate of the difference between ET and TAI, and since the SI second was defined so as to make it equal to the ephemeris second within the error of measurement. It will be possible to use most available ephemerides as if the arguments were on the new scale. Before 1955, when atomic time is not available, the determinations of ET can be considered to refer to the new scale. The offset has been expressed in the recommendation as an exact decimal fraction of a day since the arguments of theories and ephemerides are normally expressed in days.

3. In view of the desirability of maintaining the continuity of TAI and of avoiding the confusion that could arise if it were to be redefined retrospectively, no step in TAI is proposed. Although the recommendation is in terms of TAI, in practice astronomers will use UTC and convert directly to the dynamical time-scales.

4. The terminology and notation for dynamical time-scales require further consideration in due course.

5. Recognizing that the TAI second differed from the SI second between 1969 and the present by $(10\pm2)\times10^{-13}$, a step will be introduced in the scale interval of TAI. Therefore, the epoch of the dynamical time-scale for apparent geocentric ephemerides was adjusted to 1977 from 1958 at a subsequent meeting of Commissions 4 and 31.

NOTES ON RECOMMENDATION 6

1. There are not enough independent determinations of the masses of Ceres, Pallas and Vesta to derive ranges of uncertainty, but the internal standard errors are $\pm(0.3,\ 0.2,\ 0.1)\times10^{-10}$, respectively. (Ref: Schubart, J., Astron. & Astrophys. 30, 289, 1974 and 39, 147, 1975; Hertz, H. G., Science 160, 19 April 1968.)

2. Masses of satellites of Jupiter are derived from Pioneer 10. Mass of Titan is derived from the motion of Iapetus. Mass of Triton is estimated from the motion of Neptune. (Ref: Anderson, J. D., et al, J. Geophys. Res. 79, 3661, 1974; Duncombe, R. L., et al, Fundamentals of Cosmic Physics 1, 119, 1973.)

3. For Mercury, Venus, Earth, Mars and Moon the values refer to the planet's crust. A value for Venus including the height of the cloud layer is 6110 km. The radius of the Moon implicit in Watts' profile of the lunar limb is 1 738.065 km. For Jupiter the value is based on determinations from Pioneer 10 and 11. For Saturn, Uranus, and Neptune the values are means of the best optical measures by double image micrometer and heliometer. The value for Pluto is a crude estimate. (Ref: Howard, H. T. et al, Science 185, 12 July 1974; Bulletin Geodesique 118, 365, Dec. 1975; Anderson, J. D., Review of Geophysics and Space Physics 13, July 1975; Null, G. W., Anderson, J. D., Wong, S. K., Science 188, 476, 1975; Anderson, J. D., EOS of Amer. Geophys. Union 55, May 1974; Kaula, W., et al, Geochimica et Cosmochimica Acta 3, 3049, 1974; Dollfus, A., Surfaces and Interiors of Planets

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<u>and Satellites</u>, Academic Press, New York, 1970.)

4. For notation see Eckhardt, D. H., <u>The Moon</u> <u>6</u>, 127, 1973. Earth - coefficients are given for the only three terms that have a significant effect on the orbital motion of the Moon. They should not be considered as defining the dynamical model of the Earth. They are consistent with the first three terms of the presently available models of the Earth's potential, but end figures are subject to change. Mars - derived from Mars-orbiter data. The coefficients given are the ones having a significant effect on the orbital motion of satellites. Jupiter - derived from Pioneer 10 and 11 results. Saturn and Neptune - derived from motions of their nearby satellites. Uranus - based on optical measures of the flattening and is in reasonable agreement with the dynamical determination. (Ref: <u>Bulletin Geodesique</u> <u>118</u>, 365, Dec. 1975; Anderson, J. D., <u>EOS of Amer. Geophys. Union</u> <u>55</u>, May 1974; Null, G. W., Anderson, J. D., Wong, S. K., <u>Science</u> <u>188</u>, 476, 1975.)

5. The values are best estimates based on lunar laser ranging data and spacecraft data. (Ref: Liu and Laing, <u>Science</u> <u>173</u>, 1017, 1971; Sjogren, W., <u>J. Geophys. Res.</u> <u>76</u>, 7021, 1971; Gapcynski, et al, <u>Geophys. Res. Lett.</u> <u>2</u>, 353, 1975; Williams, J., <u>EOS Trans. AGU</u> <u>56</u>, 236, 1975.)

6. Several additional quantities must be specified before ephemerides can be completed, but definitive values cannot be selected at the present time. Such quantities are the secular acceleration of the Moon, the corrections to the equator and equinox of the FK4, and the rotational elements of the planets.

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R. L. Duncombe
W. Fricke
P. K. Seidelmann
G. A. Wilkins

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COMMISSION 5 : DOCUMENTATION (DOCUMENTATION)

Report of Meetings, Friday 27 and Saturday 28 August 1976

PRESIDENT : J.-C. Pecker SECRETARY : L. Remy-Battiau

1. PRESIDENT'S REPORT

The report is adopted on the motion of W. Fricke.

2. MEMBERSHIP

The loss of two deceased members of the Commission : P. Bourgeois and F. Henn was noted with regret.

Besides the two new members co-opted since the Sydney meeting and whose membership has already been approved by the Executive Committee : R.S. Dixon and L. Remy-Battiau, the following proposals were accepted, subject to approval by the Executive Committee : W. Bidelman, J.O. Fleckenstein, R.F. Griffin, S.A. Mitton, F. Ochsenbein, L. Schmadel, C.E. Worley as new members. G. Bérardini, A. Berthelot, P. Dale, J. Duncan, G. Feuillebois, G. Grassi Conti, M. Guidoni, D.A. Kemp, N.A. Lavrova, J. Mead, P. Morholt, R.B. Rodman, R.A. Seal, V. van Brunt, K. Zadla were elected or re-elected as consulting members, for the next three years.

3. OFFICERS OF THE COMMISSION, 1976-1979

According to the rules of the Commission, J.-C. Pecker and W.D. Heintz are reconducted for another three years period respectively as President and Vice-President. The Commission adopted the following composition of the Organizing Committee: D.A. Kemp, J. Kleczek, P. Lantos, J.R. Shakeshaft, T.S. Sherbina-Samojlova, G.A. Wilkins.

4. SECONDARY PUBLICATIONS

The account by W. Fricke that the Heidelberg Institute may in the future be discharged of the responsability of producing Astronomy and Astrophysics Abstracts, led to the formulation of a resolution which the Commission voted unanimously, including the consulting members, and which was so important that it was voted separately and specifically by the General Assembly (Resolution No. 3).

5. ICSU AB

W.D. Heintz reported on the last General Assembly of ICSU AB, held in Washington D.C., which he has attended as representative of the Commission. This concerned large fields of information and the major point of the meeting concerned the planning of interdisciplinary projects in cataloguing. No mention was made of UDC 52.

J.-C. Pecker reports that ICSU AB has put forward a classification for Physics in which Astronomy, Geophysics,... are considered as parts of Physics and not separately as in UDC. However, comments from members of the Commission to improve ICSU AB classification and to have it differ as less as possible from UDC 52 have been taken into consideration. Since the two classifications are essentially different in nature, it remains that we have now two different classifications. The Commission believes that UDC 52 corresponds better to the needs of astronomers.

Despite this difficulty the Commission believes that the IAU should keep its membership within ICSU AB in order to be able to express its views on astronomical and technical problems.

The Commission regrets that the relations between the different International Unions are not closer. In particular, it is inadvisable that many different organizations should each develop their own independent systems for classifying and indexing knowledge, whether this knowledge is in the form of publications or data banks.

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6. WORKING GROUP ON NUMERICAL DATA

Report for 1973-76

The Chairman of the Working Group on Numerical Data, G.A. Wilkins, gave a brief summary of the report of the Working Group on Numerical Data for the period 1973-75 (see Transactions of the IAU, vol. XVIA, part I, pp. 193-194). In addition, he had amended the "Survey of Astronomical Data Activities" that had originally been prepared for the Sydney Meeting ; the IAU Executive Committee had declined on grounds of cost to print it in an IAU Information Bulletin, but he was grateful to C. Jaschek for publishing it in the Information Bulletin of the Stellar Data Center at Strasbourg. He had attended the 1976 General Assembly of CODATA as the delegate of the IAU and had been appointed Chairman of the Committee on the Geosciences. CODATA has set up a Task Group on the "Methodology of handling space and time-dependent data" and he hoped that astronomers would both contribute to and benefit from its investigations and recommendations.

IAU Colloquium No. 35

G.A. Wilkins also gave a short account of the IAU Colloquium No. 35 on "The compilation, critical evaluation, and distribution of stellar data" which had been held at Strasbourg on 19-21 August, 1976. He was grateful to C. Jaschek and other members of the staff at Strasbourg for all the work that they had done to organize the Colloquium. There had been five sessions each with an invited speaker and contributed papers. The principal topics discussed and the invited speakers were : standards for the presentation of data (M.S. Davis), acquisition and processing of techniques (G. Westerhout), the critical evaluation of data (Miss A. Underhill), the distribution of data (B. Hauck), and exerting facilities (C. Jaschek) ; the last session had included a general discussion on current problems and future development, and as a result several proposals would be put forward for consideration by Commission 5.

Organisation

G.A. Wilkins reported that he had had discussions about the future organisation of the activities of the Working Group and as a consequence he suggested : (a) that it be renamed the "Working Group on Astronomical Data" ; (b) that it have a small organising committee ; (c) that specific projects should be carried out by sub-groups as required ; and (d) that information about the data activities of the Group and of the Commissions should be published in the Information Bulletin of the Stellar Data Center at Strasbourg. These suggestions were accepted by the Commission, which then went on to consider the resolutions and projects that had been discussed at the Strasbourg Colloquium.

Bibliographic catalogues

The following resolution on the transcription to machine-readable form of certain handwritten bibliographic catalogues was adopted unanimously :

> Commission 5 recognizes the great value of the handwritten bibliographic catalogues on the spectra of stars, compiled by W.P. Bidelman of the Warner and Swasey Observatory, and on eclipsing binaries maintained by F.B. Wood at the University of Florida, Gainesville, and recommends that these catalogues be transcribed into machine-readable form as soon as possible so that the information in them can be made available to astronomers throughout the world.

Use of Computers

It was agreed that the Chairman should set up a small sub-group on computer

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technology and standards, to study new developments of interest to astronomers and to recommend standards to facilitate the exchange of information in machine-readable form.

Guide on Presentation

The Commission confirmed the general view at the Strasbourg Colloquium that there is a need for a "Guide on the Presentation of Astronomical Data in the Primary Literature", on the lines of CODATA Bulletin No. 9 for experimental data ; such a Guide could be incorporated in the IAU Style Book. G.A. Wilkins agreed to continue the preparation of such a Guide in consultation with the members of the Working Group on Editorial Policy and others ; it would be referred to Presidents of Commissions for comment.

Designation of astronomical objects

There was a general discussion on the problems of the designation of astronomical objects ; at present, one object may have several designations, or none, and one designation may refer to several different objects. In order to alleviate the first problem, W.P. Bidelman suggested that there should be an order of preference for existing catalogues, and that the positions of objects not yet included in catalogues should be used for identification purposes. H.K. Eichhorn-von Wurmb suggested that the positions should be expressed in galactic coordinates. It was pointed out that it would be difficult to get agreement to an order of preference, since the appropriate catalogue number would depend on the field of interest, and that the precision required for the position would depend on the type of object and the wavelength of observation. There was general agreement to the suggestion by C. Jaschek that ambiguity would be avoided if Editors would ensure that all abbreviations to catalogues were clearly identified in each paper. It was also agreed that the Chairman should set up a sub-group to study these problems, consult the Commissions concerned and prepare recommendations for consideration at the next General Assembly.

Draft Organisation of the Working Group on Astronomical Data at September 1976

Chairman : G.A. Wilkins.
Vice-Chairman : B. Hauck.
Organising Committee : R.S. Dixon, C. Jaschek, Z. Zadla, (ex-officio) W.P. Bidelman, M.S. Davis, J.-C. Pecker.
Subgroup 1 : Computer technology and standards. Chairman : M.S. Davis. Members : F. Ochsenheim and two others.
Subgroup 2 : Designation of astronomical objects. Chairman : W.P. Bidelman. Members : R.S. Dixon, A. Moffat, J.R. Shakeshaft, F. Spite.
Subgroup 3 : Presentation of astronomical data. Chairman : G.A. Wilkins. Members : R.H. Garstang, C. Jaschek, J.R. Shakeshaft.

7. WORKING GROUP ON EDITORIAL POLICY

After an exchange of correspondence, it has been agreed that the new Chairman of the Working Group will be J.R. Shakeshaft, from the day of this meeting, in replacement of A. Maxwell who has asked to resign.

J.R. Shakeshaft reports as follows :

"The efforts of the Working Group during the past three years have been devoted to the preparation of a revised version of the IAU Style Manual which, it is hoped, will be adopted by many astronomical periodicals as their Style Manual. A draft has been circulated to the Working Group and the comments received, together with those forthcoming from members of Commission 5 at the General Assembly, will be incorporated in a further draft to be circulated more widely. If possible, a version upon which there is a broad agreement among members of Commission 5, and

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editors of astronomical iournals will be produced before the next General Assembly.

It should be emphasised that it is NOT the aim of the Working Group to eliminate the individuality of the various journals as regards the essential matter of content, but rather to promote a common policv with respect to the "mechanical" matters of references, abbreviations, symbols and units, in order to save the time of authors and editors, and to reduce ambiguities and uncertainties for the readers.

Many of the changes from the earlier versions of the IAU Style Manual follow from adoption of recommendations by the International Standards Organization. Potentially the most contentious is the recommendation of the use of S.I. Units, which are not the units being taught to science students in most schools and universities, following adoption of the International System by the General Conference on Weights and Measures."

Then the problem of refereeing was discussed : as a result of the instructions given by the editors towards some severity, controversial papers are often rejected, although their stimulating role should not be neglected. It has been suggested that editors remind the referees of the limitations of their role.

A short discussion on the cost of IAU publications led the Commission to adopt a resolution which was voted by the General Assembly specifically because of its wide importance (Resolution No. 2).

8. WORKING GROUP ON UDC 52

Chairman : D.A. Kemp

The Universal Decimal Classification, Class 52 (Astronomy) has been revised in view of three different aims, that it could be used for arranging books on library shelves, as entries for catalogues and bibliographies and in conjunction with computational retrieval systems. In its revised form UDC 52 is a so-called "facettes" classification based primarily on astronomical bodies. It is described in Document PC 75-7, 1975 issued by the "Fédération Internationale de Documentation".

Moreover a preliminary edition of the "Handbook on the use of UDC in Astronomy" realized by D.A. Kemp, G.A. Wilkins and V. Bacau, will be available by the end of 1976 from the Royal Greenwich Observatory. A copy of this document will be sent to all members of Commission 5. It contains primarily instructions and suggestions on how the classification may be used. The Commission carried unanimously the following resolution :

The Commission 5,

in view of the excellent and comprehensive work achieved by the Working Group appointed to undertake the revision of the Astronomical Class of Universal Decimal Classification (UDC), in cooperation with the International Federation of Documentation (FID),

recommends the formal approval by the General Assembly of the IAU of its proposals concerning UDC 52, as described in the preliminary document PC 75-7 of FID, dated March 31st, 1975, and in other forthcoming documents,

recommends the publication of this document, and its appropriate diffusion by the IAU, and

recommends all publishers of primary and secondary journals, and all astronomical libraries, to adopt the UDC 52 as revised, to make it known and to put it in operation as much and as soon as feasible, as well as revisions of the IAU style book to be elaborated by Commission 5 and its Working Group on Editorial Policy.

The future tasks of the Working Group will be the following. First, to prepare an index of UDC 52 based on alphabetical order of key words. A list of concordance between UDC 52 and the thesaurus of Astronomy and Astrophysics Abstracts should also be settled in view of future computering work.

A short colloquium on UDC 52, open to astronomers and librarians should be organized, may be in Edinburgh. It could be sponsored by the IAU.

Another task for the Working Group should be the implementation and diffusion of UDC 52. A letter should be sent broadly telling about the Handbook on UDC 52 and how to purchase it.

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Class 51 (Mathematics) has been revised and a "Permuted index of terms" has just been published by the University of Grenoble Science Library. Class 53 (Physics) has not been revised ; it would be advisable for the Working Group to participate in the revision of Class 53 and to advice the best classification to use in astronomical libraries in the meanwhile.

9. BRIEF REPORTS

P.G. Kulikovskij has announced the publication of the first volume of the "Bibliography of books and papers published on the History of Astronomy" edited jointly by IAU Commission 41 and the Moscow Academy of Sciences. Advices and comments are hoped from Commission 5.

G. Feuillebois reports on the publication at the end of 1976 by Mansholt Publishing Co. of : "Catalogue des ouvrages d'astronomie des 15ème et 16ème siècles conservés dans les bibliothèques d'observatoires européens" by G. Grassi-Conti. Mrs Grassi Conti is now preparing the continuation of this work for publications of the 17th century.

M.D. Heintz reports that no progress has been made in the completion of the "New Directory of Astronomical Institutes in the World". The need for such a work is now greatly diminished since most Astronomical Institutes addresses may already been found in the "Bibliography of Non-Commercial Publications of Observatories and Astronomical Societies" published by the Utrecht Observatory. On the other hand C. Jaschek is ready to send to anybody who requests it a list, realized by the Strasbourg Stellar Data Center, of all Institutions where there is at least one IAU Member.

G. Feuillebois and D.A. Kemp will write a note to appear in the Strasbourg Information Bulletin on Information retrieval systems usable in Europe.

Joint Meeting of Commissions 5 and 41, 31 August 1976

Chairman : J.-C. Pecker

RARE BOOKS IN OBSERVATORY LIBRARIES

The following papers have been presented :

The Census of 16th Century Books in Observatory Libraries (G. Grassi Conti)
La Bibliothèque de l'Observatoire de Paris (G. Feuillebois)
The Uppsala Observatory Collection (N. Olander)
The Crawford Collection in Edinburgh (M. Smyth)
The San Fernando Observatorio Collection in Cadiz (Almorza)
The Census of Copernicus "De Revolutionibus" (O. Gingerich)

A. Mikhailov, absent from Grenoble, could not deliver his paper on The Pulkovo Observatory Collection.

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COMMISSION 6: ASTRONOMICAL TELEGRAMS (TÉLÉGRAMMES ASTRONOMIQUES)

Report of Meeting, 30 August 1976

PRESIDENT: P. Simon. SECRETARY: B. G. Marsden.

After welcoming those in attendance, the President announced the proposals of E. Roemer for incoming President and J. Hers for incoming Vice-President, while F. Biraud, C. U. Cesco, E. Everhart, J. Grindlay, K. A. Pounds and L. Rosino were proposed as new members of the Commission. These proposals were unanimously accepted.

The President had previously submitted to the Finance Committee his recommendation that the Central Telegram Bureau continue to receive a subvention from the IAU. (The Finance Committee accepted this recommendation, the amount of the subvention approved for the triennium 1977-79 being S Fr. 5595.-)

The Secretary then brought up the continuing problem of the proliferation of material received for publication on the IAU *Circulars*. The resolution adopted by the Commission in 1973 had helped to curb the amount of this material actually published, but the problem was obviously a more wide-ranging one. Of course, from the point of view of the Central Bureau, the problem could be resolved rather easily by an even stricter application of the 1973 resolution. On the other hand, the Bureau recognized that there is a need for the moderately rapid dissemination of important new observations of phenomena that are not necessarily transient: telescope time has to be scheduled several months in advance, and since it also takes several months to get a paper published in even the most cooperative journals, a whole observing season can pass before readers can make supplementary observations. Several points were made during the ensuing discussion. It appears that some of the conventional astronomical journals tend to discriminate against papers that are entirely observational in nature and expect each unusual observation to be accompanied by some kind of interpretation. Commissions 40 and 48 were also concerned with the problem, and while it was agreed that Commission 27's *Information Bulletin on Variable Stars* provided a suitable outlet for many optical astronomers, radio and x-ray observations were not being taken care of in this way; and although Commissions 40 and 48 could consider instituting their own publications, such a move would be regressive when so much of modern astrophysical research involves the coordination of optical, radio and x-ray data. What seemed to be needed was a publication, separate from but perhaps somehow associated with the IAU *Circulars*, where short observational papers would receive a bare minimum of refereeing and editing, where they would be photo-offset from the original typescript and airmailed to subscribers in batches within three or four weeks of receipt by the editor. An *ad hoc* committee, consisting of Biraud, Grindlay, Marsden (Chairman), Martynov and Rosino, was appointed to examine the situation further and to make some appropriate recommendations.

F. Biraud enquired whether it would be possible to produce cometary ephemerides in which aberration had been allowed for completely. The Secretary replied that this was really a matter for Commission 20 to consider, but that he was prepared to provide individual ephemerides, corrected also for parallax, on a limited basis. The Secretary also agreed to implement P. Wehinger's suggestion that it would be useful to include the Central Bureau's telex (and telephone) number on each IAU *Circular*. Finally, the incoming President proposed a vote of thanks to the outgoing President and the Secretary for their services to the Commission.

COMMISSION 7 : CELESTIAL MECHANICS (MECANIQUE CELESTE)

Report of Meetings, 25 and 28 August 1976

PRESIDENT: P. J. Message SECRETARY: A. H. Jupp

25 August 1976

BUSINESS SECTION

1. Membership

It was agreed that the following persons should become members of Commission 7: V.K. Abalakin, K. Aksnes, G. Balmino, D.G. Bettis, O. Calame, J.R. Dormand, R. Dvorak, H.K. Eichhorn, A. Fiala, C. Froeschlé, N.P. Grouschinsky, D.C. Heggie, J. Henrard, V.K. Kholshevnikov, D.G. King-Hele, P. Lala, J.P. Lazovic, V. Matas, T.B. Omarov, W.J. Robinson, H. Scholl, P.K. Seidelmann, A.T. Sinclair, J.W. Siry, J. Yoshida.

It was agreed that the following persons should be invited to become consulting members, for a period of three years: R.R. Allan, V.R. Bond, J. Roels, C.J. Brookes, C. Marchal, J. Moser.

2. Election of Officers

President V. Szebehely, Vice President Y. Kozai, Organising Committee E.P. Aksenov, V.A. Brumberg, M.S. Davis, A. Deprit, G.N. Duboshin, G.E.O. Giacaglia, E.A. Grebenikov, M. Henon, G. Hori, P. Kustaanheimo, P.J. Message, B. Popovic, J. Schubart, P.K. Seidelmann.

3. Working Group on Program and Data Banks

The Chairman, Dr. M.S. Davis, stated that the Working Group had not done much since its inception, but the time now seems propitious to go forward with its work for a number of reasons. The Commission was reminded of the purposes of the Working Group: 1. To collect and disseminate information on program and data relating to celestial mechanics. 2. To recommend standards for programs and data. 3. To serve as a clearing house for questions related to 1. and 2. above.

The Working Group in its earlier report (see the IAU Proceedings of the XIVth General Assembly at Brighton, 1970, p.93) defined three kinds of data: 1. Observational data. 2. Numerical data derived from theories. 3. Analytical data.

It was pointed out that observational data is now the domain of the Centre de Données Stellaires (CDS) in Strasbourg, while the data described by 2. and 3. are still of interest to members of the celestial mechanical community. In view of this, Dr. Davis remarked that the name of the Working Group adequately describes its functions and recommended no change of title.

Dr. Davis further remarked that he had recently spoken with Dr. Jaschek, Director of CDS, who said that his Centre was willing to store all programs and data fields submitted to it by Commission 7, as well as distributing directories, programs and data files. He indicated that there are now 500 subscribers so that information and files are assured of wide distribution in the astronomical community.

The Working Group will issue a questionnaire to complete an existing,

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rudimentary directory of programs and data. The completed directory will be available through CDS and, later, in a general directory including all the sciences involved in CODATA (Committee on Data in Science and Technology, sponsored by the International Council of Scientific Unions, of which the IAU is a member) which has already published one directory and is now completing a more up-to-date one.

For the next term of the Working Group, the following slate of members was recommended: V. Brumberg, J. Chapront, M. Davis (Chairman), A. Deprit, G. Janin, W. Jefferys, H. Kinoshita. Dr. Davis also recommended that the chairman of the Working Group have the authority to co-opt other members who might be useful to the efforts of the group. These recommendations were accepted without dissent.

4. The Three-Body Problem

It was agreed to set up an ad hoc committee to look at ways of presenting numerical results in the general gravitational problem of three bodies. (It is hoped that eventually a consensus can be reached in regard to a recommended style of presentation). Dr. Hadjidemetriou agreed to act as chairman of this committee and it was decided to ask Drs. Henon, Broucke and Grebenikov to serve as members. It was understood that the committee will present a report in due course.

REVIEW PAPERS

1. The General Gravitational Problem of Three Bodies (V. Szebehely)

Previous major reviews of the subject were prepared by Marcolongo, covering the period 1686 to 1919, by Whittaker, for 1868-1898 and by Leimanis whose partial review of some aspects of the problem emphasizing Soviet contributions is the most recent available.

The literature of the problem during the last three or so years has been enriched by major contributors whose partial list includes Aarseth, Aqekian, Aksenov, Anosova, Arenstorf, Batrakov, Benest, Bettis, Bhatnagar, Boggs, Bozis, Broucke, Brumberg, Christides, Contopoulos, Delie, Deprit, Dunham, Duboshin, Easton, Efimov, Elmabsout, Erdi, Feagin, Ferraz-Mello, Froeschlé, Garfinkel, Giacaglia, Goudas, Grebenikov, Guillaume, Hadjidemetriou, Hagihara, Hamid, Harrington, Heggie, Hénon, Henrard, Herget, Hori, Janin, Jefferys, Kozai, Kunitsin, Marchal, Martinez, Markellos, McGehee, Merman, Message, Michalodimitrakis, Monaghan, Moser, Musen, Nacozy, Nahon, Pollard, Robinson, Roels, Saari, Scholl, Schubart, Sconzo, Shenal, Sharma, Siegel, Simo, Smale, Solovaya, Sperling, Standish, Stiefel, Subba-Rao, Szebehely, Tung, Vagner, Valtonen, Vidyakin, Waldvogel, Williams, Yoshida, Zare, and Zikides.

These papers make use of the essential classical results of Birkhoff, Chazy, Euler, Hill, Jacobi, Lagrange, Poincaré, Stromgren, Sundman, Whittaker and Wintner.

The three major areas of progress during the last three years may be found in, (i) partitioning the phase space, (ii) establishing new families of periodic orbits and, (iii) the studies related to triple collision and regularization. In the following these three areas are discussed in detail.

(i) Partitioning of the phase space. The principal problem in dynamics may be considered the proper and detailed partitioning of the phase space regarding the behaviour of the dynamical system. In other words, a qualitative (if not quantitative) description of the general behaviour of the system is desired for any given set of initial conditions. Several attempts to offer such partitionings based on establishing bifurcation sets, where the topological classification of the manifold of motion changes, appeared in the mathematical literature since 1970, but projections into the configuration space have been offered only recently. Existence-proofs and descriptions of regions in the configuration space where motion cannot occur are available today for the general problem of three bodies, quite similarly to the so-called Hill surfaces or surfaces of zero velocity that are well known for the restricted problem of three bodies. This breakthrough in the qualitative classification of possible motions of the general problem was achieved by three different approaches, almost simultaneously. The parameters controlling the surfaces separating forbidden and possible regions of motion are the angular momentum (c) and the total energy (h) of the system of three bodies. The dimensionless combination $(c^2h)/G^2m^5)$ plays the role of the Jacobian constant and the bifurcation sets are established by evaluating the above parameter at the libration points - again quite similarly to the restricted problem. Here G is the constant of gravity and m the average mass of the system. An important result is that for all values of h and of c the zero-velocity surfaces are open and, therefore, escapes are always possible. This fact supports Birkhoff's original conjecture according to which the set of points of the phase space corresponding to non-escaping orbits has zero measure. Another important result is that the stability of classical triple stellar systems and of planetary systems may be now studied with the new approach of establishing forbidden regions of motions. For instance, previous investigation of the stability of the Sun-Jupiter-Saturn system by means of the restricted problem showed that Saturn may not enter the regions of motions of the Sun and Jupiter, but the validity of this result is questionable since the model of the restricted problem is not truly applicable. On the other hand, when the same problem is investigated using the model of the general problem, the result becomes dynamically meaningful. In fact it can be established that Saturn may escape the system but the Jupiter-Sun binary system is permanent. The way Birkhoff's conjecture was modified by Szebehely does not allow the escape of Saturn since according to the modified conjecture a triple close approach is necessary for escape. Such a triple close approach is not allowed by the zero-velocity surfaces, therefore, the stability of this simplified model of the solar system seems to be assured, in a way quite similar to Hill's result concerning the stability of the moon's orbit. The stability of classical triple stellar systems becomes a study of the possibility of exchanges. As long as the outer member of the triplet does not interrupt the motion of the inner binary we speak of stability - remembering that the escape of the outer member is always possible since the surface is open. On the other hand, if the surfaces do not allow "interplay" or "mixing" or "exchanges" then no close triple approaches can occur and the outer member will not escape. The ratio of the pericenter distance of the outer star $q_2 = a_2(1-e_2)$ to the semi-major axis of the inner binary a_1 is the parameter controlling the stability of the system. With equal masses and for circular orbits, numerical integration gives the condition for stability that $q_2/a_1 \geqq 3.5$ while from the study of forbidden regions we have $q_2/a_1 \geqq 3.2$; indeed a remarkable agreement considering the significant difference between the two approaches. (Unfortunately the agreement breaks down for infrequently occurring counter-rotational systems, and the zero-velocity surfaces give a much higher q_2/a_1 value than the numerical integration).

(ii) Periodic orbits. During the past three years, an impressive number of families of periodic orbits were discovered. The development in this field seems to be so rapid that it is difficult to account for all the results. It is hard to resist to note that in 1953 an (erroneous) non-existence proof for other than Lagrangian periodic orbits appeared in the literature. This was followed by the discovery of single periodic orbits with collisions in a fixed system of coordinates. The next step in the development was the establishment of pseudo families of periodic orbits with variable masses, also in a fixed system. With all three masses having fixed values, no families can be established in a fixed system, therefore, the discovery of true families of periodic orbits made use of rotating systems - quite similarly to the restricted problem of three bodies. The existence of such families has been shown by analytic continuation from the restricted problem and the actual computation of these families is presently in progress. The difficulty of organizing the results of numerical integrations is considerable as may be shown in the following way. We may start from one member of one family of the restricted problem for a given value of the mass parameter μ. (There exist at least 20 well established families of two-dimensional symmetric periodic orbits for a given value of μ and the asymmetric, multiple periodic and three-dimensional families have only been sampled up to date). This periodic orbit of the restricted problem may be continued (unless its period is $2k\pi$) by increasing the mass of the third body from $m_3 = 0$ to $m_3 > 0$ and a group of periodic orbits of the general problem may be obtained with varying values of m_3. We may now take one member of this group with, say $m_3 = a$, and using this periodic orbit of the general problem we may establish a family of periodic orbits, all members having the same masses, that is m_1, m_2 and $m_3 = a$. In this way a true family of the general problem is generated. This process now may be repeated for all members of the group mentioned above. But every group comes from one periodic orbit of the restricted problem whose orbit is a member of a certain given family. The families change with μ and the number of all possible families is not established. Therefore, the number of periodic orbits of the general problem that may be established in this way is at least ∞^6. A few conclusions in the form of conjectures rather than in the form of well established theorems may be stated: (a) All families are composed of relative (to the rotating frame) one parameter periodic orbits. (b) These orbits may be perturbed resulting in quasi-periodic orbits corresponding to the class of orbits known as interplays. (c) Some of the families terminate in classical triple systems with the third star at infinity. (d) The stable behavior of some of the established periodic orbits indicates that other than classical triple systems should exist. The stability of some of these orbits excludes the possibility of escapes, contradicting Birkhoff's conjecture. But since no stable families with triple close approaches have been established yet, Szebehely's conjecture seems to be valid. It must be remarked that at present there are only a few scattered results concerning the set of ∞^6 periodic orbits. Not even all classes of Stromgren's orbits of the restricted problem have been continued yet, not much is known about the effect of μ, only two-dimensional symmetric orbits have been studied in detail, termination principles have not been established and very few families are known that were not generated by continuation.

(iii) Triple collision and regularization. When the total energy of the system of three bodies is negative, escape is proceeded by a triple close approach and it is followed by the formation of a binary. The escape velocity has been shown to be arbitrarily large and the associated binary to be arbitrarily close, (i.e., with an arbitrary small semi-major axis) if the triple approach is arbitrarily close. The fact that triple collisions in general cannot be regularized, points out the difficulty encountered in the numerical integration of triple close approaches. The numerical and analytical problems of triple close approaches on one hand and their importance in producing escapes and in forming binaries on the other hand, may be considered another case when nature successfully hides its true face. Significant analytical results regarding the one-dimensional problem and semi-analytical techniques for the one-dimensional case have been accomplished recently, so that escape velocities and directions may now be predicted. Binary collisions have been regularized for about 75 years and some of these methods are presently being applied to the regularization of the three-dimensional general problem of three bodies. Local regularizations (in the sense of Birkhoff) are available with regularization of the two smallest distances. The methods may require the relabeling of the particles as the motion proceeds. Global regularizations (i.e., elimination of the singularities for all possible binary collisions) also became available recently.

2. The Motion of Artificial Satellites (Y. Kozai)

In the first few years after the Sputnik various theories on motion of artificial satellites were published by several authors, most of them treating the main problem and/or effects due to the air drag on the orbits. In most of the papers for the main problem, solutions with the accuracy of ten to the minus six during about one thousand revolutions were derived by using the disturbing functions containing short-periodic terms of the first order and secular and long-periodic terms up to the second order. Luni-solar gravitational, solar radiation pressure and other zonal, as well as non-zonal gravitational perturbations, were derived with the same accuracy in several papers during the same period.

Since then the tracking accuracy for satellites has been increased by

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introducing radio doppler and laser ranging techniques, and it has been claimed that the ranging accuracy by laser can be as high as a few centimeters, corresponding to ten to the minus nine for close satellites, and the position accuracy by doppler tracking is a few decimeters. Therefore, in order to extract full information from tracking data, theories on artificial satellite motions with ten to the minus nine accuracy are needed.

Kozai (1962) published a second-order theory of the main problem, in which perturbations referred to Keplerian ellipses in Delaunay variables were derived by use of Hamiltonians including short-periodic terms up to the second order and secular and long-periodic terms up to the third order. Since von Zeipel transformations were applied to eliminate two angular variables one by one from the Hamiltonians the old sets of the angular variables and the transformed sets of the action variables appear in the solutions, and, therefore, the solutions were transformed so that the old variables are expressed as functions of the transformed variables. That is, the osculating elements are expressed as functions of slowly varying elements including secular and long-periodic terms (primed variables), and the long-periodic terms are expressed as functions of mean elements changing secularly (doubly primed variables). In this way, expressions for the short-periodic terms became much simpler, although those for the long-periodic terms could not be simplified.

The expressions can be written in closed form with respect to the inclination and the eccentricity. Later P. Sconzo checked Kozai's expressions by an IBM computer with FORMAC language. M. Gaposchkin and his colleagues reformulated them by their computer algebraic program called SPASM.

K. Aksnes (1970) published another second-order theory by use of Hill variables. He adopted as the intermediary orbit a rotating ellipse which is the exact solution of the equation of motion with the force function $(GM/r)\left[1-J_2P_2/(pr)\right]$. Therefore, his disturbing function is $(GMJ_2P_2/r^2)\left[(1/r)-(1/p)\right]$. He applied Lie-Hori transformations to the Hamiltonian to eliminate periodic terms. Since the Lie-Hori transformation is not an implicit one, it is not necessary to make any inversion to derive the final solution. Further, since he used Hill variables, he could derive the perturbations directly in coordinate and velocity and could thus avoid the singularity at zero eccentricity. It should be mentioned that his expressions are very compact compared with those by Kozai. His solutions were compared with those by numerical integrations, and it was found that the discrepancy is within 30m for the first-order theory and 30cm for the second-order theory after 9,000 minutes of time.

A. Deprit and A. Rom (1970) published their third-order theory of the main problem. They developed their theory with the computer algebraic program MAO by applying Lie transformations to the Hamiltonian. Since they could not find a way to express the solution in a closed form of the eccentricity, the solutions had to be developed into power series of the eccentricity up to the sixteenth power. They used modified Delaunay variables, $F=\ell+g$, h, $C=e\cos g$, $S=e\sin g$, L and H to avoid the singularity at zero eccentricity. They also expanded the solutions into power series of $(1-5H''^2/L''^2)$ which appears as a divisor for most of the other theories. Their solutions were compared with those by numerical integrations for satellites ANNA 1B and Relay II. For ANNA 1B the deviations are within 20cm along track, and 5cm across track after 200 days; for Relay II they are within 2.4m along track, and 10cm across track after 350 days. Kinoshita and Kutuzov checked their solutions with their computer programs.

H. Kinoshita (1976) developed his third-order theory with the computer algebraic program SPASM by including J_3 and J_4 terms in the geopotential. His expressions are expressed in the modified Delaunay variables, and there d'Alembert characteristics hold as he applied Hori's transformations to the Hamiltonian. His solutions were also compared with those by numerical integrations for three satellites, Geos 3, Starlette and Lageos. The deviations in the short interval of time, corresponding to two revolutions, are extremely small; namely, 0.2mm for Starlette. However, the discrepancy becomes 1cm after 40 days in track component. Therefore, it can be concluded that the third-order theory is enough for short-periodic perturbation computations even if the tracking accuracy is as high as 1cm. Without the third-order terms the deviations are as large as 10 to 20 cm.

For deriving long-periodic perturbations some difficulties for small eccentricity may arise by most of the methods, as X. Berger (1975) pointed out. Berger solved the Lagrange equations by a computer algebraic program, and found that as he proceeded to higher-order perturbations higher powers of the eccentricity appeared as divisors in his expressions of long-periodic perturbations. Therefore, the convergency of the expressions is very slow for the small eccentricity case. The same difficulty arises if von Zeipel's transformation is applied to the transformed Hamiltonian to eliminate g'. However, if the equation with the transformed Hamiltonian is solved directly, under the assumption that the eccentricity is so small that the cubic power can be neglected in the Hamiltonian, then the exact solution can be derived as,

$$e \cos g' = (1-A)\, e_0 \cos g'',$$
$$e \sin g' = (1+A)\, e_0 \sin g'' + B,$$

where e_0 is an integration constant, A is a constant with J_2 as a factor and B is another constant with J_3 as a factor. We can use these expressions for an extremely small eccentricity case. If e and g-g" are expressed as functions of g or g" by solving the expressions, the convergency is found to be very slow when e_0 and B are of the same order of magnitude. This difficulty has been avoided in Kinoshita's solution, as he applied Hori's transformation and d'Alembert characteristics hold in any order.

As the tracking accuracy has been increased, very small perturbations which had been neglected in earlier days should be taken into account. Namely, effects due to the precession and nutation motions of the earth's equatorial plane, the earth tides, ocean tides and so on. These effects were also formulated by several authors. Generally speaking, the perturbations due to the solid earth are one tenth of the corresponding direct luni-solar perturbations for close satellites, and ocean tidal effects are roughly one tenth of the solid tidal effects.

The accuracy to compute the luni-solar perturbations has been increased by several authors, and the solar radiation pressure perturbations have been treated more carefully than before by including the earth albedo perturbations. However, it is still very difficult to compute the radiation pressure perturbations with sufficient accuracy. Therefore, now satellites with very small values of area-to-mass ratio, such as Starlette and Lageos, and a surface force free satellite, Triad, are in orbit to make easier accurate orbit computations.

However, the most difficult problem still has not been solved. Nobody has ever tried to solve the equations of motion analytically, including all the forces together.

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3. Impact of lunar laser ranging on Celestial Mechanics (J.D. Mulholland)

28 August 1976

Members were asked to sign letters of best wishes which Dr. Message was sending to former presidents of Commission 7 Professor Hagihara and Professor Duboshin, who were unable to be at the General Assembly.

REVIEW PAPERS

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1. Planetary Theory Developments (P.K. Seidelmann)

The developments in planetary theories during the period 1973 to 1976 are reviewed. The emphasis in numerical integrations has been upon the methods of obtaining the specified accuracy through automatic adjustments of the step-size and determinations of the order required. Thus, for current numerical integrations the problem and the accuracy desired are specified, where as previously, the problem, step-size and the order had to be specified.

A number of approaches are being pursued to develop computer methods for generating general theories for the planets. At the Bureau des Longitudes, general planetary theories in terms of the osculating elements are being developed in both algebraic and numerical expressions and by both ordered and iterative approaches. At the Institute of Theoretical Astronomy, a mathematical construction of the series for eight major planets in accordance with the series of Krasinsky is completed. Brumberg continues to investigate iterative methods. At the Naval Observatory, a combination of iterative and ordered approaches is being used to generate numerical general theories, particularly for the inner planets.

The emphasis in theoretical developments concerning the motion of minor planets has centered on motions near commensurabilities, stability of planetary systems, and the distributions of the minor planets near the Kirkwood Gaps.

2. Evolution of Orbits in the Solar System due to Tidal Friction and other Long-Term Effects (S.F. Dermott)

Direct calculation of the long-term evolution of orbits in the solar system due to either point-mass gravitational interactions or dissipative effects is not, at present, possible and we are forced to consider indirect approaches to the problem. A useful approach is to analyse the gross dynamical structure and to seek out those features which are characteristic of a dynamically evolved system. A simple, but highly successful, example of this approach involves the rotational periods of the various bodies in the solar system. These bodies can be divided into two groups: those for which the rotational period is about 8 hours and all others. The deviants from the isochronism of spin rule must be suspected of dynamical evolution and in all cases, except that of Mars which is anomalous in this respect, there are various other features which support the hypothesis that the spins have been braked by tidal interactions.

The features of the dynamical structure of the solar system which one would expect to yield information on its evolutionary history are: the distribution of mean motions; the distribution of mass, particularly in the satellite systems; and various properties of the 7 or 8 resonances (or orbit-orbit couplings as they are sometimes called) which exist in the solar system - such as the probability of capture into resonance, the conditions for stability, the present amplitudes of libration and the present values of the inclinations and eccentricities.

The distribution of mean motions is of particular importance. In 1954, A.E. Roy and M.W. Ovenden showed that the number of occurrences of commensurabilities between pairs of mean motions in the solar system as a whole is greater than would be expected to occur by chance if the mean motions were randomly distributed. Their analysis was modified by P. Goldreich and by myself, but the result still stands; thus we must suppose either that for some reason the satellites and planets were formed preferentially at the commensurabilities, perhaps, but not necessarily, in a state of stable resonance, or that since the time of formation orbital evolution has occurred.

Recent observations of the terrestial planets have revealed that Mercury does not keep one face permanently turned towards the sun but has a rotational period which is exactly 2/3 of its orbital period. The spin of Venus was shown to be retrograde and almost exactly an integral multiple of its synodic period. Spin-orbit coupling, as the phenomenon is now called, is another example of resonance and the dynamics has many features in common with that used to describe the orbit - orbit resonances observed in the satellite systems. Roy and Ovenden's paper and observations awakened interest in the dynamical evolution of the solar system and much recent research has been concerned with the origin and evolution of the observed resonances.

In analysing the preference for near-commensurability amongst pairs of mean motions, I consider it important to distinguish between firt-order resonance and higher-order resonance. It is also desirable to treat separately those ratios involving satellites and those ratios involving planets. The near-commensurate ratios are not the only ratios that can yield information on the dynamical evolution of the various subsystems in the solar system.

Let n'/n ($n>n'$) be a ratio of mean motions and let the definition of c, a measure of the preference for near-commensurability, be given by $c = 2(a-b)$ with

$$a = \{n/n-p'/(p'+q')\}/\{p/(p+q)-p'/(p'+q')\},\ b = 0 \text{ if } a \leq \tfrac{1}{2},\ 1 \text{ if } a > \tfrac{1}{2}$$

where $p/(p+q)$ and $p'/(p'+q')$ are the two fractions which bound n'/n from above and below and max (q, q') is the maximum order of resonance that is being considered. Then $-1 \leq c \leq +1$ and the preference for near-commensurability increases as c tends to zero. If the distribution of n'/n is random then the distribution of c is rectangular.

T. Gold and P. Goldreich suggested that the preference for exact resonance in the satellite systems of Jupiter and Saturn is the result of orbital evolution due to tidal friction. This is a good example of a process which will certainly result in a characteristic distribution of ratios of mean motions. Tidal forces are highly dependent on the distance of the satellite from the planet and thus we must expect n'/n to increase with time (n is the mean motion of the inner satellite). After appreciable orbital evolution we should observe not simply a preference for $c = 0$ but also an absence of small positive values of c. This is just the distribution of c that is observed - and only in the satellite systems.

In the planetary system there is only a single example of exact resonance (that involving Neptune and Pluto whose mean motions are almost exactly in the ratio 2 to 3), but there is a definite preference for near-commensurability amongst the pairs of mean motions of the outer planets, that is, Jupiter, Saturn, Uranus, Neptune and Pluto. This preference obviously cannot be accounted for by the tidal hypothesis and we must suppose either that it is the result of orbital evolution or that the outer planets were formed in near-commensurate orbits. The latter hypothesis could be extended to include the satellites if we add that only in the latter systems has orbital evolution since formation driven the bodies into stable resonances.

Two-body resonance is not the only form of orbit-orbit resonance possible. Resonances of the type $An_1-(A+B)n_2+Bn_3 \simeq 0$ also exist. I have pointed out that this relation implies that ratios of relative mean motions are commensurate, and I have proved that in the solar system there is a strong preference for near-commensurability amongst ratios of this kind. Again, this observation cannot be accounted for by the tidal hypothesis.

The tidal hypothesis can be resolved into a number of problems all of which demand a solution. We must show that tidal forces are capable of changing <u>ratios</u> of mean motions. Changes of at least 7% are needed to account for the observed distribution of c. We must show that capture into resonance is not only possible but also probable and that the resonances are stable under the action of tidal forces. If we allow, as we must, that our position in time is not special, then the ages of the resonances, as deduced from the rates of change of the amplitudes of libration (or some other parameter characteristic of the age of the resonance), must not be too small compared with the age of the solar system. Finally, we must identify an adequate source of energy dissipation.

The rate of change of the orbital radius a of a satellite of mass m is given by

$$\frac{da}{dt} = \frac{f(q)}{Q} \times \frac{m}{a}\ 11/2$$

where Q is the tidal dissipation function and f(q) a function of parameters of the

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planet only. As a first step, it is reasonable to take Q as proportional to the pth power of the amplitudes of the tidal force, which itself is proportional to m/a^3. The integration of the differential equation then gives the appropriate result

$$\log a_o = \left(\frac{1-p}{13/2-3p}\right) \log m + \left(\frac{\text{constant}}{13/2-3p}\right)$$

in which a_o is the present orbital radius.

For the Saturnian satellites, Mimas, Enceladus, Tethys, Dione, Rhea and Titan, a plot of $\log a_o$ against $\log m$ is a good straight line of slope corresponding to $p \sim -2$. This feature would appear to be strong evidence in favour of the tidal hypothesis, but there are serious problems associated with the implied amplitude dependence of Q. Using the stability condition of the Mimas-Tethys and Enceladus-Dione resonances, which is $(\dot{n}'<n>) < (n<\dot{n}>)$, and a more general form of Q which incorporates a factor equal to the sth power of the frequency, it can be deduced that

$$-1/6 < p \lesssim 0,$$

$$-2/3 < s \lesssim 0.$$

This suggests that Q is amplitude and frequency independent. In which case neither the observed mass distribution nor the formation of the Titan-Hyperion resonance can be accounted for.

It is tempting to speculate that p and s are not zero and that a correct treatment of the non-linear tidal interactions would take care of all the problems. I do not agree with that view. I consider that there is evidence in favour of the tidal hypothesis but that Q is probably amplitude and frequency independent. I list the following points:

1. the observed distribution of ratios of mean motions in the satellite systems suggests that these ratios (of n'/n) have increased with time;
2. the values of Q, as deduced from the present orbits of the inner satellites, are so very high ($\sim 10^5$) that it would be surprising, particularly if parts of the planets are solid, if tidal evolution had not occurred;
3. the large amplitude of libration or equivalently, the low age ($\sim 4.10^8$y) of the Mimas-Tethys resonance and the low age ($\sim 4.10^8$y) of the Enceladus-Dione resonance are best accounted for by the tidal hypothesis with Q amplitude independent;
4. all three resonances in Saturn's satellite system have been shown to be stable under the action of tidal forces provided that Q is amplitude and frequency independent.

It needs to be pointed out that tidal forces are not always efficient at changing ratios of mean motions. As the orbital radii of a pair of satellites, which are not in resonance, separately increase with time, the ratio of their mean motions tends to a constant value. Further, da/dt itself decreases rapidly as a increases and thus, for orbital evolution due to tidal friction, we should expect the commensurabilities to be encountered in the early stages of evolution and for the resonances to be nearly as old as the solar system. The only exceptions should be those cases in which the ratio a'/a is consistent with the aforementioned constant value relation, as the commensurability will then be approached comparatively slowly. Once in resonance, the rate of change of the amplitude of libration, will also be correspondingly slow. The Mimas-Tethys and Enceladus-Dione resonances are young. The amplitude of libration of the Mimas-Tethys resonance is still large and the eccentricity of Enceladus (the feature which characterizes the age of the Enceladus-Dione resonance) is still small. Both of these pairs almost satisfy the previously mentioned constant value relation, with p = 0. I consider this to be strong observational evidence in favour of the tidal hypothesis with Q amplitude independent.

The fact that $m/a^{13/2}$ is approximately the same for Mimas, Enceladus, Tethys and Dione or, equivalently, that a plot of log a against log m for these satellites can be roughly fitted by a straight line with slope corresponding to p = 0 is only weak evidence in favour of the tidal hypothesis. For if Mimas has always had an orbital radius greater than that of Janus then the initial values of $m/a^{13/2}$ could not have been very much different from the present values.

The important work of A.T. Sinclair, R.J. Greenberg and others on capture into resonance has shown that the observed two-body resonances in Saturn's satellite system could be the result of orbital evolution. If $\langle \dot{n} \rangle$ is finite and certain stability conditions are satisfied, then capture into resonance is not only possible but also probable. The calculated probabilities of capture do not, however, depend on the evolutionary mechanism and so, although the results support the hypothesis that the resonance are the result of orbital evolution, they do not support the tidal hypothesis in particular. All three resonances in the Saturnian system, however, have been shown to be stable under the action of tidal forces and this in itself is evidence in favour of the tidal hypothesis.

COMMISSION 8: POSITIONAL ASTRONOMY
(ASTRONOMIE DE POSITION)

Report of Meetings, 25, 28 August, 1 September 1976

PRESIDENT: G. van Herk SECRETARIES: B. L. Klock, H. J. Fogh Olsen, R. H. Tucker

Business Matters

I. REPORT

The President's Report was approved without discussion. Copies will be distributed to the Members as soon as they become available.

II. OFFICERS AND NEW MEMBERS

President: Tucker, Vice-President: Høg, Organizing Committee: Anguita, Débarbat, Fricke, Klock, Marcus, Nemiro, Schombert, Tavastsherna, Teleki, Van Herk, Yasuda;
New Members: Bem, Chernega, Chollet, Dravkikh, Gay, Grudler, Gubanov, Gulyaev, Johnston, Kharin, Lederle, Manrique, Raimond.

III. BY-LAWS

The proposed By-Laws, written by Tucker, were translated into French. These were extended following a suggestion by Tucker, adopted and translated back into English. They will be circulated to all Members.

Reviews on current Problems

I. STATUS REPORTS

a. W. Fricke dealt with the situation of the work on the FK5 (July 1976). There will be an improvement of the individual positions and p.m. and in the system of the FK4 and an extension to stars as faint as 9th magnitude. The team (Bien, du Mont, Gliese, Lederle, Strobel and Walter) at Heidelberg has collected information from all material available, where especially the Pulkovo- and U.S. Naval Observatories are thanked for their cooperation. Billaud's work on astrolabe results is mentioned. No new evidence of large systematic errors in the FK4 have become known since the report of 1973. A list of catalogues was circulated (and can be obtained on request) for the purpose of having its completeness checked. Further material is urgently requested. New catalogues with differential observations can still be incorporated if they are received before June 1978; absolute observations should not come in later than December 1977. The fainter stars are selected from a master-catalogue (AGK3R, SRS and PZT programs combined). Standards are set up for the older observations to fulfill. Six or more catalogue positions are available for 2297 stars north of -5^{o}, and three or more for 2411 stars south of -5^{o}. It is not yet sure whether all these older observations are free from magnitude errors. The inclusion of catalogues prior to 1900 cannot be considered (inadequate observational technique, magnitude equations, unknown polar motion). Dieckvoss asks about the date of the Equinox. This will be answered in the Joint Session with Commissions 4, 19, 31 and 40. Kharin: Will the 1977 observations of the Sun and Planets be included? Reply: No, they will come too late.

b. J.L. Schombert reported on the SRS program. The final results have been reported by Abbadia, Bordeaux, Nikolaiev, Perth (Hamburg), San Fernando, Tokyo, San Juan and Pulkovo (α). By the end of 1976 the following observatories expect to finish their reductions: Bucharest, Cape (Herstmonceux), Pulkovo (δ) and Washington. The SRS will be reduced to an improved FK4 system. The $\Delta\alpha_{\delta}\cos\delta$ differences with the

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FK4, obtained at Perth, El Leoncito and Santiago-Pulkovo show, from +30° to -90° a very satisfactory resemblance. Fricke, Gliese and Høg discussed the system to be used in the reduction.

c. H. Yasuda reviewed the NPZT program. The final results from Abbadia and Bordeaux have been received (the last ones having an accuracy of ± 0ˢ0086 (reduced to the Equator) and ± 0.″203); the expected data of delivery from the other observatories range from 1977 till 1981. A list was given, showing the distribution of NPZT stars with some observational history for every hour in RA and 5 declination zones.

d. Y.S. Yatskiv gave an account of the status of Astrometry in the USSR. He presented papers from: Polozhentsev, Meridian Astronomy in the USSR; Lengauer, Corrections for Chromatic Refraction when employing photoelectric and other methods for determining Star Positions; Nefed'eva, The new Tables of Astronomical Refraction; Polozhentsev, Stellar data and Computing Facilities at the Pulkovo Observatory; Orelskaya, On the present State of observations of Asteroids selected for improving the Star Catalogue Positions; Nemiro, Piljugina, Tavastsherna and Shishkina, Catalogue of Absolute Right Ascensions of 1023 Bright and Faint Stars (Pu-58); Ivanov, Kirjan and Kirjan, The Two-coordinate Photoelectric Micrometer.

New instruments, reduction techniques and methods of observation were described. Six observatories continue the compilation of catalogues.

	all cat.	abs. cat.	N $\times 10^3$
AOE, Kazan MC	6	2	40
GAISH, Moscow MC (2)	18	1	92
Golosseevo VC	5	1	62
Kharkov MC	8	-	44
Kiev MC	7	-	49
Nikolaev MC VC PI	13	5	191
Odessa MC	16	-	73
Pulkovo MC VC PI HMC A PVC	33	8	485
Tashkent MC	13	2	95

The total number of catalogues produced in the last 35 years is given in the table. The mean errors for the best observations are now $\varepsilon_\alpha \cos\delta = \pm 0\overset{s}{.}011$ and $\varepsilon_\delta = \pm 0\overset{''}{.}25$. Gliese: Out of the 144 catalogues I have received, 96 came from the USSR. Fricke: Will the method to observe declinations at a station near the Earth's equator (Murry and Kreinin) be executed?-It will. Van Herk asked about the work done on Spitsbergen. Yatskiv: Preliminary results are already obtained. The maximum period of continuous observing has been 52 hours by three persons. Anguita: Is Pulkovo's PVC working now? Yatskiv: The instrument is now under investigation in the workshop.

II. INSTRUMENTATION AND RESULTS

a. E. Høg discussed the instrumentation, the working and the accuracies of his slit micrometer, used by the Hamburg expedition to Perth. The results are most promising. Klock: How accurate has Mars been observed? Høg: A mean error of ±0.″20 was obtained. Dieckvoss: How faint will you eventually come? Høg: With the use of a tracker instead of a fixed slitsystem, one could probably go 2-3 magnitudes fainter, provided the proper accompanying equipment is involved.

Høg offered a copy of Lindegren's summary on the work done on planets with a multislit micrometer. The displacement of the photocentre relative to the geometrical disk centre is found from formulae and is largely confirmed by the Hamburg-Perth observations. Some displacements (Venus to Jupiter) have to be determined experimentally at different phase angles. Accidental mean errors of one observation of ± 0.″18 ($\Delta\alpha\cos\delta$) and ± 0.″30 ($\Delta\delta$) are reported.

b. H.J. Fogh Olsen showed that the $\Delta\delta_\delta$ between the recently finished MC catalogue at Brorfelde and the AGK3 has an unexplained jump of the order of 0.″3 at δ = 40°. These $\Delta\delta_\delta$ depend on the AGK2 as well as p.m. have been applied. The only physical explanation seems to be the change of measuring machines at 40° for the AGK2 plates, a possibility strongly denied by Dieckvoss. Fricke: Use the latest AGK3 edition. Lacroute: Compare your work with the Strasbourg edition. Anguita: How many fields of optical counterparts of radio sources, and how many stars per field do you observe? Fogh Olsen: 41 fields are observed with an average of 15 stars.

c. E. Høg discussed the differences Perth-FK4 for 1200 stars. No differences depending on clamp position were found. There is a good agreement with the results obtained at Santiago. Gliese: How absolute is the azimuth determination? Høg: The

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azimuth is relative to FK4 stars on an arc of 140° of the meridian.

d. B.L. Klock reports on the status of the Northern TC Division at Washington. The 6" has been much changed since 1973: a new objective, a new glass circle, a circle scanner, inductosyns rebuilt (read-out 0".05, pointing within 1"). The ATC has been temporarily equipped with a visual micrometer and has been moved to Arizona.

e. I. Pakvor read Mitič and Pakvor's paper on the use of vacuum tubes to observe meridian marks. The vacuum is at the moment (reply to Jackson) a few tens of mm, the m.e. of one reading is 0^{s}005. The required tolerances for the stability of glass sealings and the tube itself could be fulfilled.

f. Pakvor read S. Sadžakov's paper on the differences in Dec for stars in common to the AGK3 and the General Catalogue Latitude Stars. Systematic errors in AGK3 are small.

g.F. Chollet (i.l. of Débarbat) explained the set up of the filter needed to bring the excessive amount of sunlight down to that of the full moon to observe the Sun with the astrolabe. The observations are made now E and W of the meridian with satisfactory results; the necessary constants are taken from the night observations.

h. C.A. Murray discussed the need for a continuation of classical MC work even with all the rumours of space astrometry around. There will remain a great need to compare results of old and new techniques. MC observations will also be badly needed to help find reliable positions of radio objects. In this context the next fitted in:

i. K.C. Blackwell gave the results of an investigation of the movement of the Equinox. The Greenwich solar observations and Morrison's discussion of lunar occultations seem to indicate a movement which can be expressed as a quadratic function of time. To settle this matter: continuous observations of the members of the solar system, including the Sun, are urgently requested. Klock replies to Murray that the Washington observations of Sun and planets will be available in about 18 months. Walter replies to Débarbat that six fundamental stars are radio sources.

j. At the request of Klock, the President commented on the need to make notes on which component of double stars were observed: p, f, n, s, br or fa. This habit seems to have gone lost through the fargoing automation.

III. WORKING GROUPS

a. G. Teleki reported on the work done on Refraction. The new Pulkovo Refraction Tables (5th ed.), a collaboration of Soviet astronomers and the Working group, is now being prepared. An averaged atmosphere is taken for the whole globe with regional characteristics; asymmetry of the atmosphere is taken into account. Only data for cloudless nights are used. Chromatic refraction will be calculated from spectrophotometric gradients. B-V values are the best substitutes; astrometric catalogues should include these values. The chromatic characteristics for the detector must be given. A simplified version of the refraction corrections is given by Nefed'eva, based on the Soviet Standard Atmosphere Gost-73. Kolchinskij's use of the geodetic methods of determining terrestrial refractions has led to a value at z=90° (288.2K, 1013.25 mb at the surface) of 33' 5".5, much lower than what theories claim. Harin and Fukaya are cited to what can be obtained from the methods to correct refraction from U and L culminations. The model of the northern hemisphere is from Sugawa and Kikuchi, based on data given for each 10th degree of latitude and longitude.Regional- as well as time variations are reported. The mean average asymmetry in NS direction is twice that in the EW direction.

b. G. Billaud dealt with the Astrolabe Contributions to FK5. Results from different catalogues cannot be compared easily as they depend on three unknowns (chaining constants). A systematic sinusoidal effect in the $\Delta\alpha_\alpha$ and $\Delta\delta_\alpha$ could not be explained and was corrected for. The comparison of the coordinates from two catalogues gives equations of condition where one of the required unknowns has to be chosen, after which the differences can be expressed in the same scale. In RA a translation, in Dec a translation and a rotation can occur when the solved unknowns show small errors. From 18 catalogues 1139 $\Delta\alpha$ corrections to the FK4 (m.e. 4ms) were computed, and 943 $\Delta\delta$ corrections (m.e. 0".07). In both hemispheres some important effects with respect to the FK4 (up to 10 ms and 0".15) were found. Fricke complimented Billaud warmly for the excellent job he has done. Requieme was reluctant to correct for effects from unknown sources. Eichhorn commented on the completely different outlook of these systematic differences compared to what one is used to see from MC work and asked Fricke how these results will find their way into FK5. Fricke: the results will be used for individual corrections and to some extent for the improvement of the FK4 system.

Resolutions

1. Commission 8 approves the new program (proposed by the Institute of Theoretical Astronomy in Leningrad) concerning observations of the selected minor planets for solving the problems of fundamental astrometry and asks the observatories having appropriate equipment to take part in the observations according for this program. The results should be presented in such a manner that later improved reference star positions can be taken into account.

2. Commission 8 approves the initiative of the Kiev University Observatory which has begun compilation of the general catalogue of the Bright Stars (BS) and asks the observatories which have taken part in the observations of these stars to send their results to the Kiev Observatory. In addition, it is agreed that the Kiev University Observatory shall make the data available to other establishments working on the same program.

3. Commission 8 supports the plans of the Hamburg-Bergedorf Observatory for a fourfold coverage of the northern hemisphere on overlapping plates.

4. Commissions 8 and 24 endorse the collaboration between Denmark and the United Kingdom for operating the automated Carlsberg Meridian Circle on a good observing site and support the proposed observing program for this and other automated meridian circles for solving the problems of fundamental astrometry and providing positions of reference stars and of stars of astrophysical interest.

5. Commissions 8 and 24 together, noting the great progress which may become possible by the use of space astrometry in defining the reference system, in trigonometrical parallaxes, and in proper motions, support strongly the study and possibly the realization as quickly as possible of astrometric observations from space. This must not affect the planning of ground-based programmes before the accuracy, reliability and long-term continuity of space astrometry have been assured.

6. In accordance with Resolution No 5 of Commission 8 adopted at the XVth General Assembly at Sydney, Commission 8 resolves that:

a. All SRS observations of each star for each night should be made available by the observatories together with the final positions derived from them.

b. The observations of the FK4 stars made with the SRS observations should be made available in the same way.

c. The SRS observations should be reduced to an improved FK4 system which is to be derived jointly by the Pulkovo Observatory and the U.S. Naval Observatory in consultation with the Astronomisches Rechen-Institut on the basis of absolute and/or semi-absolute observations near the epoch 1970. This system shall be called SRS Preliminary System. The relation between the SRS Preliminary System and the FK4 has to be specified explicitly.

d. A complete SRS catalogue should be preserved at the U.S. Naval Observatory and at the Pulkovo Observatory. This should be made available on request. In addition to the mean values for each star, this catalogue should include all individual observations with the weights and the systematic corrections which were used in forming the mean values.

e. The AGK3R and SRS catalogues should be made available in the system of FK5.

f. In order to ensure that the AGK3R and SRS will provide an adequate reference system in the future the observations of SRS must be repeated and it is strongly recommended that the AGK3R be also reobserved.

7. Commission 8 recommends the application of Kreinin and Murri's method of determining absolute declinations at a station situated near the Earth's equator.

8. Noting the great improvements of accuracy and efficiency of observations by means of photographic and photo-electric techniques already obtained, and to be

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expected, Commission 8 encourages observers to employ these new techniques.

9. For the refinement of astrometric measurements for the establishment of a highly accurate fundamental system Commission 8 agrees that the development and application of optical astrometric instruments (transit circles, astrolabes, et cetera), radio interferometers and space telescopes are necessary.

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COMMISSION 9: INSTRUMENTS AND TECHNIQUES (INSTRUMENTS ET TECHNIQUES)

Report of Meetings August 25, 26, 27, 31, 1976

PRESIDENT: A. B. Meinel

The 8 scientific sessions of Commission 9 were organized on the basis of Working Groups by the Chairman of each group. In addition, two Joint Discussion sessions were held with Commission 12 and organized by R. G. Giovanelli. The business session elected J. Ring as President and E. H. Richardson as Vice President. The Commission voted to drop inactive members as determined from results of a poll of all the membership. Fourteen new members were added. The five Working Groups were continued, the new President to review chairmanship and composition of these groups. Discussion of a new Working Group on Auxiliary Instrumentation showed that the rapid advances in this field and the wide interchange of instrumentation on major world telescopes may make such a group desirable. The President and Comite d' Organization are to deal with this matter.

A draft resolution was prepared by the Working Group on Data Acquisition and Processing and endorsed to the General Assembly: Whereas astronomers are rapidly moving toward use of separate auxiliary on-line instrumentation on many telescopes around the world, the question of interface standards is of major importance. Commission 9 therefore urges adoption of international computer language standards proposed by IEEE (HPIB language) and IEC (CAMAC language) for instrumentation data handling interfacing. The Working Group also requests that it study whether definition of a universal real-time language for on-line instrumentation is possible and/or desirable.

WORKING GROUP ON LARGE TELESCOPES

The session of the Working Group on Large Telescopes was organized by J. Rosch. I. M. Kopylov described the 6 meter telescope and showed early photographs taken at prime focus with a Maksutov field corrector. Image diameters of 0".8 were obtained. A limiting magnitude of 25 was reached at F/4 in 45m exposure on 103a-0 plates. G. Cayrel described the joint French-Canadian-U.S. 3.7m telescope being erected on Mauna Kea, Hawaii. E. J. Wampler described performance of the 4m Anglo-Australian telescope at Siding Spring Australia. A. B. Meinel presented progress on the Multiple Mirror Telescope (MMT), a joint project of Smithsonian Astrophysical Observatory and University of Arizona, showing optical test results for the six 1.7m mirrors indicating 90% of the light within 0".5. C. Kuehne described the Zeiss 0.75m alt-azimuth telescope and associated control system.

A supplemental session devoted exclusively to the Soviet 6m telescope was arranged by J. Rosch at which the Chief Engineer for the project, B. K. Joannisiani described the telescope, its construction details and performance. He also described the problems of making, polishing and mounting the 42-ton borosilicate (Pyrex) glass mirror. In spite of the short notice for this meeting, it was well attended.

WORKING GROUP ON PHOTOGRAPHIC PROBLEMS

Mr. William C. Miller was elected Chairman of this new Working Group during a meeting of Commission 9 in Sidney, 1973. Mr. Miller retired from the Hale Observatories on July 1, 1975 and requested to be relieved from this office. Richard M. West was appointed chairman of the Working Group. Secretary is J. L. Heudier.

Two sessions of the Working Group were held during the General Assembly meetings on August 25, 1976. They were attended by approximately 130 astronomers. During the Working Group business session, the terms of reference for this new Working Group were established by the adoption of the following resolution: "The IAU Working Group on Photographic Problems, having met during the XVIth General Assembly in Grenoble, and recognizing the continued importance of photographic detection techniques in current astronomical research, considers as its principal

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aim to support astronomers using this technique, in particular by: promoting a rapid and efficient dissemination of information about astronomical photography in the widest sense, e.g. sensitization, calibration, exposure, processing, storage, copying, and extraction of data from exposed plates; encouraging manufacturers to develop and market new, improved emulsions for use in astronomy, while assuring the continued production of other emulsions of astronomical merit, and; striving to facilitate the international delivery of astronomical plates and films. (It was tacitly assumed that the area of electronographic emulsions belongs to the activities of the Group). In the same session, the following Organizing Committee was elected by acclamation: R. Cannon (UK), O. Dokuchaeva (URSS), J. Grygar (Czechoslovakia), K. Henize (USA), J. L. Heudier (France), D. Latham (USA), A. Smith (USA), B. Takase (Japan), R. West (Denmark). As special consultants to the Working Group were elected: Wm. C. Miller (USA), A. Millikan (USA). Chairman for the period until 1979 is Richard M. West. The Secretary of the Working Group is Jean-Louis Heudier. The scientific sessions were divided into three major topics.

Emulsions and sensitization techniques

A. Millikan: "A review of photographic image detection theory as applied to astronomy." D. Latham: "The detective performance of Kodak spectroscopic plates." A. G. Smith: "Comparative hypersensitization of Kodak astronomical plates with nitrogen and hydrogen: sensitometry and sky tests." O. Zichova and J. Grygar: "Sensitization of plates for the Ondrejov 2m telescope."

Processing and storage of photographic plates

A. Millikan: "Optimal processing of large photographic plates." W. van Altena: "Envelopes and environmental conditions for the archival storage of exposed photographic plates."

Examples of practical work

H. C. Arp: "Photography of faint surface brightness regions in galaxies." J. L. Heudier: "The photographic laboratory of the INAG Schmidt telescope." A. G. D. Philip: "Classification of objective prism spectra on IIIa-J plates." I. R. King: "Automatic measurement of photographic plates."

A supplemental working session was held, at which time it was decided that a bibliography covering publications (after 1970) of interest to astronomers using photographic techniques should be compiled and prepared for distribution early 1977. It appeared desirable to convene a meeting of European astronomers in this field some time in 1977 and the chairman was asked to take the necessary steps towards such a meeting. The question of availability of electronographic emulsions was discussed in view of recent difficulties (some manufacturers having discontinued the production) and a report will be prepared and distributed.

In view of the large interest in astronomical photography, it has been decided that no formal membership of the Working Group will be established other than a steering committee. The circular letters and reports which are issued by the Working Group will, however, be sent to all astronomers and institutes who so wish , and a distribution list is maintained and updated by the secretary. Requests should be addressed to: Dr. Jean Louis HEUDIER, U.E.R. Observatoire de Nice, F-06300 NICE - Le Mont Gros, France, or the chairman: Richard M. WEST, ESO Sky Atlas Laboratory, c/o CERN, CH-1211 GENEVA 23, Switzerland.

WORKING GROUP ON AUTOMATION AND DATA REDUCTION

Two scientific sessions were organized by E. J. Wampler. Papers were presented by P. B. Boyce, M. S. Ewing, B. M. Lasker and T. B. McCord. There was some general discussion of the possibilities and merits of standardization of computer languages and interfaces.

It is clear that since the last General Assembly, the use of mini-computers in observatories has become routine. Sixteen bit machines are most commonly used and the low cost of the central processors has permitted many users to build powerful systems. Experience has shown that to realize the full capability of the mini-computers, it is necessary to assemble systems with extensive peripherals such as disk-packs, tape drives, plotters, etc. In 1976 the cost of a mini-

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system, together with its peripherals, runs between 45 and 70 thousand American dollars. These machines are being used to automate telescopes and instruments, collect and reduce data, etc. We are moving towards a situation where complete automation of ground-based observation is feasible for many observatories. A meeting held at MIT in April 1975 discussed the situation current at that time.[1]

More recently, microprocessors have been introduced to fulfill special functions and in some cases to act as backup to a larger mini-computer. The chief limitation at present with microprocessors is that they are difficult to program. They are not a replacement for minicomputers. It was pointed out that the minimum minicomputer configurations are often a poor investment because of the difficulty of programming without such peripheral devices as a fast printer plus magnetic tape and disc.

Generally, the reliability of the electronic part of a computer system is very good, although the electromechanical parts are more troublesome and some early versions of microprocessor kits have had reliability problems.

The working group discussed the use of FORTH as a possible common language in astronomy. Although it is crash-prone and expensive, and there may be some problems of proprietary rights, those who have used it are generally enthusiastic about it. The group agreed that they would study "whether definition of a universal real-time executive programming language for on-line instrument interfacing is possible and/or desirable."

There was a discussion of the merit of a standard computer interfacing scheme such as CAMAC. CAMAC has now been adopted by some observatories, and should make it easier to move complex computer aided instruments from one telescope or observatory to another.

The WG recommends that Commission 9 and the IAU draw attention to the existence of international standards for equipment interfacing, and urges that observatories make use of these standards for new developments where appropriate.

WORKING GROUP ON INFRARED TECHNIQUES

A scientific session was organized by J. Ring. The first part of the session was devoted to a review of the new ground-based facilities for infrared Astronomy which were either in construction or planned. The requirements for an infrared telescope or flux-collector were outlined by J. Ring as follows: 1) The site must be as free as possible from absorption by water-vapour and from "sky-noise." These requirements seemed to imply a high-altitude site. 2) The collecting area should be as large as possible since for some types of observation in the infrared, the observing time was inversely proportional to the square of the area. 3) The structure should be thermally "clean." This was a problem with some attempts to convert existing optical telescopes. 4) Since daytime use was often possible in the infrared, good tracking and pointing accuracy was important.

He then briefly listed several categories of telescopes which were in the course of construction or modification, including old and new optical telescopes with infrared capability, new systems planned from the outset with a joint infrared/optical role, and specifically infrared telescopes or flux-collectors. He paid particular attention to the three new telescopes being constructed for Mauna Kea, the joint Canada/France/Hawaii telescope which was designed with infrared use in mind, the NASA 3m infrared telescope which was to have high image quality and the U.K. 3.8m infrared flux-collector which would have only 2-3 arcsecond images but which provided a large, "clean" collecting aperture very cost-effectively. He also mentioned the infrared alternative role of the M.M.T., whose optical performance had been described in an earlier session by A. B. Meinel. W. E. Brunk gave further details of the NASA telescope and L. Luud briefly outlined plans in the U.S.S.R. for infrared astronomy. Good progress was being made in the near I.R. and long-wave detectors were being investigated. It was likely that good infrared sites were available in the U.S.S.R.

The second part of the session was devoted to papers on new infrared spectrometric techniques including Michelson and Fabry-Perot interferometers, an image tube echelle spectrograph and a heterodyne spectrometer.

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J. W. Brault described two Fourier transform spectrometers which had been built at K.P.N.O. and showed examples of visible and infrared solar spectra obtained with one of them. (A fuller description of these instruments was given in the joint discussion between Commissions 9 and 12).

J. E. Beckman described an interferometer constructed jointly, by groups at Meudon, E.S.A. Noordwijk and L.P.S.P. France. It was intended for high resolution ($R \sim 2.10^4$) spectroscopy of interstellar emission lines in the middle infrared. This range, especially between 18μm and 100μm, requires the use of an airborne telescope, viz. NASA's 92cm Kuiper Airborne Infrared Observatory, and the instrument design is suited to its bent Cassegrain focus. The two-beam interferometer uses conventional optics, plane mirrors and dielectric beamsplitters. Its moving mirror employs a 15cm drive table travelling at speeds calculated to produce an audio output on the detector, centered at 80Hz. Speed, position and direction are monitored and used to control the continuous motion and take discrete data, via an HP5525 magnetically split auxiliary laser interferometer. Bandwidth is limited by helium-cooled 10% optical passband filters, in series with an electrical analog filter in the detector signal chain. The detector itself is a "3-parts" bolometer, of rugged construction , giving N.E.P. between 2 and $3x10^{-14}$ watt $Hz^{-\frac{1}{2}}$ under operating conditions.

The system operates on-line to an HP2100A computer, which controls the motion, accepts data, and yields spectra by fast Fourier transform after automatic phase correction. For astronomical work, spectra taken off source in times of order 1 minute are subtracted from relevant on-source spectra. This system has the advantage that for lines where the theoretical prediction is susceptible to errors of order 1%, the method can distinguish terrestrial from interstellar lines without ambiguity. In a recent observing run using the aircraft, lines of SIII at 18.71μm, and OIII at 88.35μm were detected from the Orion Nebula. The former was resolved, yielding a half-power velocity width of 28 $km.sec^{-1}$, in good agreement with radio recombination line data. In addition new standards of precision were set for atmospheric emission line frequencies within the 10% passbands, including those of the isotopic species of water HDO, and $H_2{}^{18}O$.

E. R. Wohlman described several interesting, high-resolution Fabry-Perot spectrometers which are in operation and under development in C. H. Townes' group at the University of California, Berkeley, for use in the 5μm, 10μm and 20μm windows. Observations have been made during the past several years with a coude-mounted tandem scanning Fabry-Perot spectrometer in series with a cooled 1% bandwidth circular variable filter. The system has a resolving power of $\lambda/\Delta\lambda \sim 10^4$ and has been used between 3μm and 13μm to observe molecular absorptions in cool stars and planets and fine-structure line emission from HII regions. The NeII 12.8μm emission from the galactic centre has been resolved both spectrally and spatially.

A single scanning Fabry-Perot interferometer in series with a cooled grating has been used in the 20μm window. The 18.7μm SIII line has been detected in emission from several sources. This spectrometer is also used at coude. A Cassegrain spectrometer designed for observations in the 10μm window is near completion. This system, also of resolving power $\sim 10^4$, employs a single cooled Fabry-Perot interferometer in series with a cooled grating. Cooling the Fabry-Perot plates and mounting the system at the Cassegrain focus will result in an improvement in sensitivity of about an order of magnitude above that of the tandem Fabry-Perot.

The principal advantage of the Fabry-Perot spectrometer is that the narrow bandwidth reduces sky noise well below the level of random photon noise at all wavelengths in the infrared. In addition, the Fabry-Perot spectrometer can be used to obtain a spectrum of an arbitrarily narrow spectral interval. For this reason, the Fabry-Perot is a particularly sensitive instrument for the study of individual emission lines.

T. R. Gull described an echelle spectrograph which has been designed for use at Cassegrain focus of the four-meter telescope at K.P.N.O. The optical design of the spectrograph is optimized with consideration of the properties of the large

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telescope to achieve peak performance for high-dispersion spectroscopy of trailed stellar objects and untrailed nebular objects with seeing-limited angular resolution.

The echelle spectrograph is proving to be very successful with over 1300 echellograms logged as of mid-July, 1976, less than two years after the first testing on the telescope. Examples of its performance are many, but include the following studies: 1) H and K line profiles in supergiants. 2) Interstellar diffuse bands. 3) Interstellar atomic and molecular lines. 4) First spectra of the x-ray flare A0620-00. 5) Spectra of several comets, including Comet D'Arrest. 6) Rotation and limb darkening of the outer planets. 7) Spectral variations of planetary satellites such as Io and Triton. 8) Planetary nebulae and their nuclei. 9) Multi-slit line mapping of planetary nebulae and HII regions. 10) First high dispersion, seeing-limited multi-slit spectra of supernova remnants. 11) Nuclei of ordinary galaxies. 12) Nuclei of Seyfert galaxies, and 13) The brightest quasi-stellar objects.

The echelle is proving to be a most useful observing tool when the extra dimension of spatial resolution is added. Its use, however, will be limited until routine data reduction techniques are developed by the supporting national facilities.

A. Betz pointed out that when resolving powers greater than 10^5 are required in the 10μm region of the infrared, heterodyne spectroscopy becomes an attractive alternative to conventional high resolution techniques. For the study of the shapes of individual line profiles of CO_2 in the atmospheres of Mars and Venus, a heterodyne spectrometer has been constructed at the University of California, Berkeley, with the following characteristics. The infrared signal received through the telescope is combined with 1 milliwatt of the coherent output power of a stabilized CO_2 laser serving as the local oscillator. The laser can oscillate on any one of a number of selectable vibrational-rotational transitions of CO_2 in the 00^01 - $(10^00,02^00)_I$ band. The combined beams are focussed on a high speed mercury-cadmium telluride photodiode cooled to 77 Kelvin, which produces a difference frequency spectrum in the radio-frequency range of 0 to 1500 MHz. After amplification, a 200 MHz segment of this intermediate frequency spectrum is converted into the band of 50 to 250 MHz by a single-sideband (SSB) mixer and then directed into a multi-channel RF filter bank, similar to the types used in microwave spectral line receivers. The oscillator frequency for the SSB mixer is chosen to center the desired line profile in the filter bank, and it is tracked in frequency to accommodate changes in source Dopler shift during the course of the observation. The filter bank analyzes the 50 to 250 MHz spectrum simultaneously into 40 independent channels of 5 MHz ($1.7 \times 10^{-4}cm^{-1}$) each. The 40 detected power outputs are synchronously demodulated at the telescope beam switching frequency of 150 Hz and multiplexed into a computer for on-line integration and analysis. After each integration cycle on the source, usually 4 minutes, a blackbody calibrator is set in the infrared signal beam. The sensitivity is measured to be 2.7×10^{-16} watts for a signal-to-noise ratio of 1 after a 1-second integration in each 5 MHz channel. However, the detection of only one source polarization and the loss of half the signal due to sky-chopping can be viewed as effectively degrading this sensitivity by an additional factor of 4. With an input infrared frequency of about 3×10^{13}Hz, a 5 MHz channel bandwidth implies a resolving power of 6×10^6. Some of the more recent results obtained with this instrument may be found in "Astrophys. J. (Lett.) 208, L141-148"; while a more general introduction to heterodyne detection at infrared frequencies is contained in the review of Blaney, which is published in "Space Science Reviews, 17, 691-702."

Summarising the discussion, Prof. Ring predicted very considerable advances in ground-based infrared astronomy when the new telescopes were followed by the powerful spectrometric tools which had been described and by the newer detectors which were emerging rapidly at present. These systems would be particularly needed to follow-up the discovery of new types of source by infrared space observations such as those proposed with the L.S.T. and the NASA/Dutch Infrared

Astronomy Satellite survey.

WORKING GROUP ON PHOTOELECTRONIC IMAGE DEVICES

Owing to the occurrance of IAU Colloquium 40 on Photoelectronic Detectors with Linear Response in Meudon immediately following the General Assembly, the scientific session of the Working Group was limited to a series of seven invited review papers, covering the field of photoelectronic image detectors. These papers were designed to review the types of devices currently available and under development and typical use, and were directed toward the average user rather than the image tube specialists.

ELECTRONOGRAPHIC IMAGE DETECTORS, D. McMullan

The characteristics of the three classes of electronographic image tubes - the "classical" Camera Electronique, the "valve" type, and the "barrier membrane" type - were discussed. Ease of operation by the ordinary astronomer was identified as the most important requirement although this can only be obtained with some sacrifice in performance. Electronographic cameras in actual astronomical use were briefly described and the problem of commercial availability considered.

IMAGE INTENSIFIERS, W. A. Baum

The development of image intensifiers dates back about 40 years, and they have been the subject of various earlier reviews, including those by W. K. Ford (Annual Rev. Astron. Astroph. 6, 1, 1966), W. C. Livingston (Annual Rev. Astron. Astroph. 11, 137, 1973), and E. J. Wampler (Methods in Exp. Phys. 12, 237, 1974). A complete list of users would include astronomers at nearly all well-known observatories of the world.

Four astronomical applications of image intensifiers appear likely to continue or to expand: (1) intensified sky photography in the near-infrared, (2) intensified photographic spectroscopy where simplicity and low cost are important, (3) image photon-counting utilizing phosphor persistence in an image intensifier as a temporary memory, and (4) image photon counting behind an intensifier using signal integration external to it.

THE PRINCETON SEC CAMERA PROJECT, M. Schwarzschild

The main engineering effort of the project aims at present at putting a SEC tube with 5 cm x 5 cm cathode and target into operation. The present smaller SEC tube has been used recently for obtaining direct images at Mt. Palomar (Morton and Williams) and at Cerro Tololo (Williams and Schwarzschild). The photometric exploitation of these images (each effectively with 350 x 350 pixels of 50 x 50μm) is in progress.

SIT SYSTEMS, J. A. Westphal and J. Krishan

SIT tubes have been in use for several years, at a number of observatories, for direct imaging, two-dimensional photometry, sky-subtraction spectroscopy, and acquisition and guiding. Their advantages include linearity over a wide range, cheapness and ready availability, a full two-dimensional format, ruggedness, large dynamic range, and simplicity and reliability. Sufficient observing experience is now available that the tubes are reasonably well understood and used routinely. Some disadvantages are the necessity for cooling to reduce thermal noise and spectral response limited to 8500 Å by the S20 photocathode and 4000 Å by the fiber optics input (although UV transmitting tubes are now available on special order). A detailed report is available in the proceedings of the IAU Symposium on detectors (Meudon, Sept. 10-13, 1976).

DIODE ARRAY DETECTORS, Robert G. Tull

The silicon photodiode has high quantum efficiency (>50%) for visible and near-infrared radiation, with a useful spectral range from 0.39 to 1.1μm. Its response is linear when used in a charge storage mode. It is also an efficient detector of sub-atomic particles and has been used as the electron multiplier in experimental photomultiplier tubes. Integrated circuit linear and area arrays of silicon photodiodes, complete with integral shift-register readout circuits and operating in the charge-storage mode, became commercially available (Reticon Corp., Sunnyvale, CA, U.S.A.) about 5 years ago.

This paper will review existing astronomically useful systems which make use of silicon diode arrays, primarily self-scanned Reticon arrays, both as direct photon detectors and as intensified detectors. Silicon and SIT vidicons, CCD's, and CID's, are excluded from this review.

Linear arrays as direct photon detectors are used in spectroscopy at the Universities of Texas, British Columbia, Arizona, Toronto, and California (L.A.), and at Lund Observatory. Electron Bombarded Silicon (EBS) arrays exist at the University of California (San Diego) and University of Texas. C. Coleman and B. Morgan in Great Britain have developed EBS arrays used behind a Spectracon tube. Arrays optically coupled to image intensifier phosphors are in use at the Universities of Wisconsin and Michigan, Hale Observatories, and Kitt Peak. Magnetographs using Reticon arrays (not intensified) have succeeded at Lockheed Solar Observatory and Kitt Peak. Non-intensified area arrays have been used at Vancouver for photometry, and at University of Texas for telescope autoguiding.

CCD AND CID IMAGE SYSTEMS, W. C. Livingston

Compared to Reticon-type arrays the charge coupled devices (CCD) and charge injection devices (CID) are well adapted to large 2-dimensional formats and low-light-level operation. Noise sources are dark current (which is eliminated by cooling with LN^2), output amplifier noise (which depends on video capacity Cu and transister channel-resistance), and surface/bulk-state trapping noise.

The CCD has the smallest value of Cu and promises a threshold detectivity of a few electrons. Its main disadvantage is related to imperfect charge transfer efficiency which leads to a loss of MTF and various photometric problems. The CID advantages include random access and non-destructive readout. The latter allows the averaging of many reads to reduce the effects of amplifier noise. The disadvantage is a large value of Cu leading to relatively high amplifier noise.

A Fairchild CCD has been used successfully by D. Wilkinson and E. Loh for nebular surface photometry (BAAS 8, 350, 1976). B. Oke, at Palomar, has experimented with a Texas Instrument 100 x 160 CCD for stellar spectroscopy. B. Smith has used a TI 400 x 400 element array for planetary imaging and arrays up to 800 x 800 are planned for the Jupiter Orbiter Probe. A general purpose CID camera employing a GE 100 x 100 array has been developed by R. A. Kens at K.P.N.O. under the astronomical guidance of R. Lynds, J. Harvey, and M. Belton. Preliminary tests for narrow band imaging on the 4m telescope are encouraging.

MICROCHANNEL PLATES AND THEIR APPLICATION TO PHOTON-COUNTING IMAGE SYSTEMS, M. Lampton

The use of microchannel plate electron multipliers has led to the development of a variety of electrooptical image intensifiers and sensors. A microchannel plate (MCP), is a planar array of several million parallel cylindrical-channel electron multipliers. Such a device offers an electron gain of 10^4 or more, and can be cascaded for yet higher electron gains. MCP's are sensitive to low energy electrons, and can also sense UV, EUV, and x-ray radiation directly. Thus they are useful in sealed visible-light image tubes and as demountable sensors in space astronomy.

The Working Group on Seeing and Site Testing was disbanded.

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COMMISSION 10: SOLAR ACTIVITY (ACTIVITÉ SOLAIRE)

ACTING PRESIDENT: G. Newkirk, Jr. SECRETARY: A. Bruzek

Scientific Sessions

Stellar and Solar Structure (Jointly organized by Commissions 10, 12, and 35) See Commission 35 Report.

How Can Flares Be Understood? Commission 10 organized a three-hour discussion on selected problems associated with the occurrence and interpretation of solar flares. A four-member panel, consisting of E. R. Priest, D. M. Rust, P. A. Sturrock, and H. Zirin had a principal role in the discussion, and the meeting was chaired by Z. Svestka. A detailed report will be published in SOLAR PHYSICS. Specific contributions included:

PART 1: MAGNETIC CONFIGURATIONS AND INSTABILITIES IN FLARES

Z. Svestka: Introductory Talk; M. J. Martres: The Relation of Flares to "Newly Emerging Flux" and "Evolving Magnetic Structures"; A. B. Severny: How Flares Can Be Understood; M. Pick: Relationship between Type III and Microwave Radio Bursts and the Role of Magnetic Configuration; M. R. Kundu: The Location and Size of Microwave Bursts; S. I. Syrovatskii: Basic Questions in Our Understanding of Flares; D. S. Spicer: The Thermal and Non-Thermal Flare: A Result of Non-Linear Threshold Phenomena; J. Reyvaerts, E. R. Priest and D. M. Rust: An Emerging Flux Model for Solar Flares.

PART 2: LOCATION OF THE PRIMARY FLARE SITE AND ENERGY TRANSFER IN FLARES

J. C. Brown: Introductory Talk; G. E. Brueckner: The Prime Energy Release and Flare Development; J. A. Vorpahl: Comments Regarding Release and Transfer in Solar Flares; K. G. Widing: Multiple Loop Activations and Continuous Energy Release in a Solar Flare; J. C. Henoux and Y. Nakagawa: Location of the Primary Flare Site and Energy Transfer in Flares; A. B. Severny: Comments on Salyut-4 Observations of Active Regions on the Sun; H. W. Dodson-Prince: The Early and Late Loops in Flares; R. Falciani: Photometric Studies of the Starting Phase of Flares; H.S. Hudson: Effects of Electrons versus Protons in the Solar Atmosphere; S. A. Colgate: Thermal Effects in Flares; P. A. Sturrock: An Overview of the Energy-Flow Problem.

Small Scale Solar Magnetic Structure (Jointly sponsored by Commission 10 and 12). Proceedings will appear in Highlights of Astronomy with F. L. Deubner and J. O. Stenflo, editors.

Reports on Results of Skylab and OSO-8 (Jointly sponsored by Commissions 10, 12, and 44)

SKYLAB FLARE RESULTS - S. Kahler

Over 200 solar flares were observed on Skylab with enough data to follow the evolution of a large fraction of those flares. In addition to active region flares, flarelike phenomena were seen in X-ray bright points and in X-ray filament cavities. The basic flare component observed by all groups is the loop, which is delineated

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by magnetic flux tubes. Loops range in size from several arc seconds to several arc minutes in length. The NRL spectroheliograph data show that heating appears to take place at or near the tops of loop structures.

The flare of June 15 has been analyzed by the AS&E and NRL groups who find evidence of continued heating well after the end of the impulsive microwave burst.

One consistent result obtained by all groups is that the calculated conductive cooling times for flares are consistently shorter than the observed cooling times. This may indicate that additional heating during the decay phase is required.

Attempts to find a soft X-ray signature of impulsive microwave bursts have not been successful. The relationship between the impulsive phase of the flare and the heating of flares is uncertain at this time.

SKYLAB CORONAL ACTIVITY RESULTS - R. MacQueen

Coronal activity observed with the Skylab telescope complement has provided a wealth of new results. Significant transient activity---coronal brightness changes at least equal to the diffuse X-ray coronal brightness over areas exceeding 10^{19} cm^2--has been seen in more than 40 events by Webb, Krieger and Rust, employing results from the American Science & Engineering Company soft X-ray telescope. These changes are manifest in long lived (3-40 hour) brightness increases of the general size scale of Hα filaments following Hα filament disappearances. These observations often imply there is a rather long-lived heating phase following the most dramatic initial phase of coronal ejection observed most readily in the outer corona in white light. Corollary evidence for this post-ejection heating phase in also found in EUV observations from the Naval Research Laboratory spectroheliograph, which show excellent temporal correlation with gradual rise and fall events long observed at radio wavelengths.

As noted above, the ejection of coronal material itself--typically 10^{15} - 10^{16} grams total--has been observed in over 100 cases with the white light coronagraph supplied by the High Altitude Observatory. These events, associated both with flare and eruptive prominence events seen on the solar disk, have velocities ranging from ~ 100 to > 1200 km/sec and thus involve kinetic energies in the range 10^{30} - 10^{32} ergs. The morphology and kinematics of a number of events have been examined in some detail, and evidence based upon the distribution of material when a number of events, and the metric wavelength radio association in a single event, presented for the dominence of magnetic forces. These transient events represent major perturbations to the local solar corona and dramatically modify the coronal evolution; however, the interplanetary (1 AU) signature of transient coronal events is yet indefinite. Their role in modifying the interplanetary medium--through electron density and/or magnetic fluctuations--is under study as is the potential role of transients in modulating the cosmic ray flux.

SKYLAB ACTIVE REGION RESULTS - E. M. Reeves

The sun is known to be highly structured in both quiet regions and in active centers, with previous space observations characterizing active regions as areas of increased temperature and density compared to the surrounding quiet sun, and with the ultraviolet line and X-ray band intensities increasing with the strength of the observed magnetic field. The improved spatial resolution of the ATM instruments in the ultraviolet and X-ray domains permitted detailed studies to be made of the complex three-dimensional loop structures which form the dominant active region morphological features at higher temperatures of the transition region and corona. Models of active region loops suggest a cooler inner core surrounded by cylindrical sheaths forming the transition to the surrounding coronal temperatures. Although the intensity along the loop can be quite constant, models indicate higher temperatures toward the top of the loop, and indicate structural scales that would be resolved only in the hotter outer regions ($T \geq 10^{6}$ °K). Formulations can also be derived to relate the size of the loop to the isothermal extent and the necessary energy input under assumptions of radiation or conduction loss mechanisms. The nature of the necessary energy input processes required to achieve the observed loop stability is not as yet understood.

The appearance of the loops provides strong evidence for inferring the dominant role of the magnetic field in shaping and stabilizing the loop structures. Coronal magnetic field extrapolations from observed photospheric fields have been undertaken by several research groups and can provide quite good comparisons with observed solar structures on a global scale, including large loop structures interconnecting active regions. Over limited regions of the sun comprising a single active region complex the field extrapolations can be used to infer field strengths and coronal pressure, and frequently provide good comparisons with the observed details. There is some evidence for force-free currents flowing in loops, which would be oppositely directed in loops on either side of the connecting line, and also evidence that some loops cannot be reproduced by potential field extrapolations. There is quite good evidence of magnetic field line reconnection above the photosphere from changes in active region loop structure observed in both the ultraviolet and X-ray regions. Loop patterns show definite rearrangements on time scales inconsistent with significant motions of the photospheric footpoint. Although there remains some uncertainty about the unambiguous interpretation of the observations, magnetic field reconnection appers to offer the most direct interpretation.

Observations of bright points in the soft X-ray and extreme ultraviolet regions indicate that they can also be represented as loop structure embedded in the chromospheric network. Although the bright points are generally small (approximately 20 arcsec) with lifetimes of about 8 hours, there appears to be continuous size and lifetime distributions over into the domain of the more classically recognized active regions. For most of these low-lying features the density is about 4 times the surrounding area but the overlying coronal temperature is comparable to that of the quiet sun.

Studies of sunspots in the extreme ultraviolet frequently reveal that they form the footpoint of many active region loops extending out to connect in the surrounding plage. When viewed from above in radiation in the range 5×10^{4} - 6×10^{5}K they appear very bright compared to the surrounding plage.

OSO-8 RESULTS - R. Bonnet

The afternoon session was devoted to the description of the results obtained by the instruments on OSO-8, both pointed toward the sun and spinning with the spacecraft's wheel, viewing the sun once per orbit. Results must be regarded as preliminary. This session included a brief description of the results obtained by the Crimean Astrophysical Observatory onboard the Soviet station Salyut 4.

The American pointed instrument on OSO-8, a high resolution UV spectrometer, was described by E. C. Bruner, Prinicipal Investigator. It consists of a small telescope, 1.8 m equivalent focal length, followed by a single channel Ebert-Fastie spectrometer covering the range between 120 and 200 nm, with a spectral resolution of ≃ 20 mA. The instrument is commanded through a small incorporated computer. Such a high spectral resolution is ideal to study flows of matter and velocity fields from the photosphere to the top of the transition region. Most observations were made with an angular resolution of 20 arcsec.

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Observation of waves with periods of 300 sec and smaller were described. Emphasis was given to the SiII lines at 181.7 nm formed at ≃ 15000°K. Intensity fluctuations of periods 240 sec and 300 sec and velocity fluctuations of 300 sec were observed over the Quiet Sun while the same observations made over a sunspot lead to periods of 180 sec for both the intensity and velocity fluctuations. Over a plage only velocity fluctuations appear with a period of ≃ 90 sec and an amplitude of 2.8 km/sec. However, no power appears at the corresponding frequency in power spectra averaged over several orbits made of this same plage. The same results hold for the C IV line at 154.8 nm formed in the transition region.

A red shift is measured over bright regions in the network and simultaneous observations in Si II and the Ca II line at 854.2 nm made at Sac Peak give a good correlation between red shifts and regions of strong megnetic fields. Puzzling systematic blue shifts were observed at the limb, and high resolution profiles of the Lyman-α line show that the solar line is red shifted with respect to the geo-coronal absorption line.

Intensity transients were observed in the C IV line which preceded by 5 min a redshift of the line and an increase in its width. A series of questions and an active discussion ensued the presentation of these results which concentrated on the significance of intensity enhancements in terms of temperature fluctuations and the low amplitude of the steady flow observed over active regions where velocities as high as 20 km/sec are expected.

S. Jordan reported on observations of the 90 sec oscillations and computations of the mechanical energy carried by waves of periods smaller than 100 sec assuming that the magnetic field is equal to zero. From the lack of 90 sec oscillations in the Si II line, he concludes that radiative losses exceed the mechanical heating.

The French instrument on OSO-8 was described by P. Lemaire. This instrument is also a high resolution telescope giving a spatial resolution of 2 arcsec followed by a 6 channel spectrometer centered on 6 strong chromospheric lines: the H and K resonance lines of Ca II, the resonance lines of Mg II in the near ultra-violet, and the Lyman-α and Lyman-β lines of hydrogen. In addition, two lines formed in the transition region O VI 103.2 km and Si III, 120.6 km can be observed nearly simultaneously with the 6 main lines. The spectral resolution achieved with this instrument is also 20 mÅ. The telescope secondary mirror can be moved to generate small rasters on the disk of up to a sqaure of 64 arcsec with steps of one arcsec.

Many results were presented on intensity and velocity oscillations in the lower chromosphere where periods of 175 sec were measured in Ca II, and Mg II. The red and blue peaks of the Mg II lines oscillate in nearly exact opposition. Apart from instrumental effects, no oscillation could be detected in Lyman-α and Lyman-β. Examples were shown of high resolution profiles made in different regions of the network, plages and sunspots. An apparent systematic asymmetry appears in the intensity of the blue and red peaks of Lyman-α showing a higher blue peak and Lyman-β a higher red peak on the average. The profiles of Ca II and Mg II in different regions of prominences show strong asymmetries and vary over areas of one arcsec.

R. C. Catura described the X-ray heliometer in the OSO-8 wheel (Lockheed Research Laboratories) which operates in the energy range 1.5 - 14 KeV with a spatial resolution of 2 arcmin.

R. Novick described the University of Columbia wheel instruments which make spectra of the whole sun between 2 and 7 KeV, measure polarization, and can also observe stars in the direction parallel to the spin axis of the spacecraft. Preliminary results on the Crab Nebula show strong polarization effects.

A. Severny briefly described the solar instruments onboard Salyut 4: (1) a crossed dispersion spectrometer operating between 97 nm and 140 nm with a spectral resolution of .315A fed by a telescope which was able to resolve ± 2 arcsec, which recorded ≈ 600 spectra of active regions, flares, prominences; (2) a grazing incidence spectrometer operating between 74 and 97 nm with no spatial resolution.

Administrative Sessions

Report of the business meetings of Commission 10 (26 August and 1 September 1976) and on the meeting of the Organizing Committee (30 August 1976).

At the beginning of the first meeting, G. Newkirk (Acting President) welcomed Mme. d'Azambuja and honoured--audience standing--the late president of Commission 10, Prof. Kiepenheuer, and L. de Feiter, late member of the Organizing Committee.

(1) Election of Officers and New Organizing Committee. The Acting President proposed a slate suggested by the present Organizing Committee and noted that a main task of the members of the O. C. is the preparation of the Commission section of the Report on Astronomy. Kundu and Pick proposed that "Energetic Particles" should be taken care of in related sections of the report by Smerd, Sturrock and Wilcox. The proposed slate was accepted unanimously.

Président: G. Newkirk, Jr.
Vice-Président: V. Bumba
Comité d'Organisation: R. J. Bray, T. Hirayama, V. A. Krat, J.-L. Leroy, S. F. Smerd, N. V. Steshenko, M. Stix, P. Sturrock, J. Wilcox, C. Zwaan.

(2) Working Groups

Working Group on International Programs (Chairman, P. Simon). Members: L. Dezso, M. Dryer, W. Kreplin, R. P. Lin, J. Rush, D. M. Rust, A. Shapley, H. Tanaka.

Working Group on Solar Maximum Year (Chairman, D. Rust). Members: Still to be established from a list of candidates proposed by the Commission.

Flare Build-Up Study (Chairman: Z. Svestka). Members: G. Brueckner, A. Bruzek, J. Harvey, M. Pick, E. Priest, D. Rust, P. Simon, S. Smerd, P. Sturrock, S. Syrovatskii, J. Vorpahl.

Solar Mass Ejections (Chairman, E. Tandberg-Hanssen). Members: To be established from a list of candidates proposed by the members of Commission 10.

(3) Working Group Reports.

(3.1) WG International Programs. P. Simon reported that the chief responsibilities of the working group are the continuity of synoptic observations, organization of new international data programs, and the collecting of data over long periods for later research requiring them. Simon noted several problems: (a) flare patrol and publication (flare reporting), (b) the sunspot program of the Royal Greenwich Observatory, (c) the coronal observations (which were not discussed further).

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The chairman had sent a memo on "Flare Patrol and Report of Subflares" to the members of Commission 10 in April 1975 and submitted another memo, "The Flare Survey Programme", to the Commission meeting. He noted that H. W. Dodson-Prince has prepared a new booklet with recommendations for flare observations.

Discussion following the WG report resulted in Recommendations or Resolutions regarding Flare Reporting, the SOON network, and the Royal Greenwich Photoheliographic Results.

(3.2) WG Solar Maximum Year (SMY). H. Zirin reported that the WG was formed at the Sydney IAU with the following membership: Athay, Bruzek, Bappu, de Jager, Dunn, C. Jordan, R. Noyes, Smerd, Stepanov, Svestka, Tanaka, Zirker, Rösch. The objective of SMY is to formulate a cooperative study of the sun by combined observations of ground based observatories and space equipment during the coming maximum. A tentative program has been developed in the "Prospectus for the Solar Maximum Year". Zirin wishes to resign as chairman because of other commitments.

Discussion culminated in the action on the SMY and the re-establishment of the Working Group.

(3.3) WG Flare Build-Up Study (FBS). Z. Svestka reported that the FBS is a common undertaking of magnetospheric and solar physicists with the objective of investigating the common processes which may occur in solar flares and in the terrestrial magnetosphere. A workshop was held last Fall (1975) in Falmouth (Mass.) and the proceedings are in print. Svestka proposed three recommendations originatint from the Workshop concerning: (1) organization of future workshops (2) observations to be coordinated by FBS and SMY during the Solar Maximum Mission, (3) support of a balanced program in solar research. The President suggested and the WG chairman agreed that only the third recommendation be brought before Commission 10.

(3.4) WG Mass Ejection. Tandberg-Hanssen reported on the history of the WG, which started as the Spray Patrol Project. He noted the expanded capability of modern observations to study many aspects of mass ejections from the sun and proposed that the WG be reconstituted to reflect this change.

(3.5) WG Ad hoc Group on Solar Nomenclature. Bruzek reported that the ad hoc group preparing the Solar Glossary was established on the initiative of the late President of Commission 10, Prof. Kiepenheuer. The group comprises the following: Beckers, Bruzek, Dodson-Prince, Durrant, Fokker, Harvey, Howard, C. Jordan, Koutchmy, Martres, Patel, Roxburgh, Svalgaard, Tandberg-Hanssen. The Glossary gives extended definitions and/or quantitative descriptions of solar terms and phenomena supported by illustrations and will be published in the Astrophysical and Space Science Library (Reidel/Dordrecht).

(4) Membership. (a) Commission 10: the President submitted a list of scientists who have applied for membership with the Commission and all were accepted. (b) SCOSTEP Executive Committee: Svestka wants to retire as IAU representative. Smerd was proposed and adopted as his successor. (c) SCOSTEP MONSEE Committee: It was proposed and accepted to replace Jaeger (Potsdam) by Bumba; Tanaka remains the other representative.

(5) Duties of Commission 10 and 12. The President raised the question of whether the division of responsibility between the two solar commissions should be re-examined. Smerd proposed that a joint WG (10, 12, and 40) should be established to bring a recommendation to the next General Assembly. The proposal was accepted and the President was requested to pursue the matter.

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SOLAR ACTIVITY

Recommendations and Resolutions

Recommendation 1

Flare Reporting - Considering the essential role of flare patrols in current solar research and in the study of solar terrestrial physics and the growing interest in possible long-term variation in the level of solar activity and noting the increasing gap in 24 hour coverage of the sun, Commission 10 recommends that the solar community support a continued, viable program for flare patrol and flare reporting during the next solar cycle.

Recommendation 2

Support of Solar Research - Reflecting upon the continuing contribution of research at ground based observatories, plasma laboratories, and theoretical institutes on the nature of solar flares;

Recognizing that large gaps in solar observations will occur between individual space missions, and being deeply concerned about the many recent abandonments of ground based programs due to lack of funds; Commission 10

Recommends: that the various national funding agencies support a balanced program of space and ground based solar research with appropriate recognition of the vital role played by ground based observatories, theoretical institutes, and plasma physics laboratories.

Resolution 1

Royal Greenwich Observatory Heliograph - The Royal Greenwich Observatory has served the solar physics community for one hundred years by the production of high quality, homogeneous, photoheliographic observations. Commission 10 of the IAU expresses its gratitude to the RGO for this valuable service to the scientific community and notes with regret that the RGO will terminate its photoheliographic program at the end of 1976.

Recognizing the need of ensuring the continuation of this long series of homogeneous reports performed during one century and noting the capability and interest of the Debrecen Observatory to continue such a program, Commission 10 encourages the Debrecen Observatory to undertake the following responsibilities:

- To carry out direct photoheliographic observations at Debrecen and,
- To organize cooperation between other observatories willing to contribute to such a project
- With the assistance of the Greenwich Observatory to ensure a homogeneous continuity of the gathering, reduction and publication of such data
- To ensure the archiving of the original photographs and this access to interested scientists from around the world.

Resolution 2

SOON SYSTEM - Commission 10 is pleased to note the development of the Solar Optical Observing Network (SOON) and thanks the U. S. Air Force for their generous offer to make the solar data gathered available to the international scientific community. Commission 10 hopes that the representatives of the U. S. Air Force and the World Data Centers will consult frequently in the near future to assure that continuity will be maintained between the new data to be generated by the SOON system and the older data of the international flare reporting system.

Other Actions

H. Newton - Commission 10 of the IAU, noting the 100th anniversary of the photoheliograph program at the Royal Greenwich Observatory, sends cordial greetings to Mr. Harold Newton, whose study of sunspots for so many years was a major contribution to the long enduring solar program of the Royal Greenwich Observatory.

Mass Ejections - Recent ground-based and space-borne observations have revealed many unsuspected properties of mass ejections from the sun. Progress in the study of these phenomena will be vastly aided as a variety of observational methods are coordinated and information on particular events exchanged among interested scientific parties.

Accordingly, Commission 10 establishes a Working Group on Mass Ejections with E. Tandberg-Hanssen as Chairman and suggested members as: J. Kleczek, M. McCabe, R. MacQueen, J. Parkinson, R. Stewart, and a representative from Commission 10 to be established by negotiation between the Chairman of this Working Group and that Commission President.

The charge to the Working Group is to:

1) Organize a system for the appropriate reporting of mass ejections to the World Data Centers

2) Define an appropriate nomenclature for mass ejections from the sun, and,

3) Encourage participation in collaborative programs for the observation, reporting, and interpretation of solar mass ejections,

4) Report these findings to the Commission at the next General Assembly.

Commission 10 recommends that the World Data Centers receive observations pertinent to mass ejections from the sun and disseminate this information through their normal channels.

Solar Maximum Year - In view of the importance of coordinated ground and space observations of the forthcoming maximum of solar activity and realizing the potential interest in establishing a program for a Solar Maximum Year on the part of Commission 10 and other organizations of the ICSU organizations for the purpose of developing a detailed plan of the program for the SMY for submission to the IAU Executive Committee at its first meeting in August 1977.

The charge to the Working Group for SMY is as follows:

To develop a detailed plan for the SMY to include:

- its scientific objectives

- the observational and theoretical work required to meet those objectives

- a plan for the coordination of the observing programs of such satellites as: solar maximum mission; international sun/earth explorer; intercosmos series; the proposed Japanese solar satellite; with ground based observatories as well as with observations which are part of the International Magnetospheric Study in order to organize the SMY to make best use of known space opportunities

- a plan for the implementation of the SMY including specifically the role of the IAU, the scope of the overall effort, and the collaborative roles expected from the various national committees, national scientific agencies, etc.

- a proposal for the structure of a permanent Steering Committee for SMY

- a specific timetable for the implementation of the SMY

- a survey of the likely cooperating observatories and spacecraft missions and their scientific contributions as proposed.

The Working Group shall prepare a draft plan for the SMY for submission to the IAU Executive Committee for consideration for adoption by the IAU at the time of its August 1977 meeting.

Rust agreed to serve as Chairman of this Working Group with the responsibility of setting up the Working Group and carrying out the above charge with their cooperation. Suggestions for membership in the Group include: I. Axford, J. Brown, A. Bruzek, L. Fisk, K. Frost, A. Gabriel, T. Holzer, C. Jordan, R. MacQueen, R. Manka, P. Simon, W. Stepanov, Z. Svestka, K. Tanaka, H. Zirin, R. Michard, E. J. Smith.

Proposals for Colloquia and Seminars - The Commission received a proposal from E. Jensen that an IAU sponsored colloquium on "Prominences and Their Solar Environment" be held in Oslo, 8-12 August 1977. The proposed Organizing Committee is to include Orrall (Chairman), Leroy, Morozhenko, and Engvold. After discussion, the Commission suggested that the objectives of the Colloquium be sharpened to take advantage of the timely emergence of such new observations as those now available from the Skylab and that the Organizing Committee be broadened to include a larger disciplinary distribution. Proposed additions to be considered should include: radio physics, Kundu; EUV, Moe; MHD, Anzer; EUV, Withbroe; coronal manifestations, MacQueen; EUV, Sheeley. A postponement of the colloquium to August 1978 should be considered. The President of the Commission and the proposers agreed to coordinate further actions in keeping with these recommendations.

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COMMISSION 12: RADIATION AND STRUCTURE OF THE SOLAR ATMOSPHERE
(RADIATION ET STRUCTURE DE L'ATMOSPHÈRE SOLAIRE)

Report of Meetings, 25, 26, 28, 31 August and 1 September 1976

PRESIDENT: R. G. Giovanelli.

25 August 1976 - Business Meeting

I. ORGANIZING COMMITTEE

The Commission elected the following Organizing Committee:
President: M. K. V. Bappu.
Vice-President: Y. Uchida.
Organizing Committee: J. M. Beckers, G. E. Brueckner, A. N. Cox, S. R. Gopasyuk, C. Jordan, W. Mattig, V. M. Sobelev, P. Souffrin, R. G. Giovanelli (ex officio).

II. NEW MEMBERS

New members of the Commission were endorsed as follows: J. E. Beckman, N. Bel, A. Bhatnagar, V. Bumba, C. Cannon, F.-L. Deubner, L. Dezsö, E. Fossat, E. M. Frazier, J. W. Harvey, S. Jordan, F. Kneer, S. Koutchmy, A. Kubičela, M. Kuperus, W. C. Livingston, S. McKenna-Lawler, M. Marik, R. Mewe, D. Mihalas, M. Semel, A. Skumanich, G. Stellmacher, V. E. Stepanov, J. O. Stenflo, K. Tanaka, W. Unno, G. Ya. Vasil'eva, M. Vukičević-Karabin, H. Wöhl, S. M. Youssef, A. Zelenka.

III. REPORT OF THE COMMISSION

The problems associated with preparing the Commission's Report for 1976-79 were discussed. While the Report for 1973-76 attempted to be an account of all activities with comprehensive references, it was generally considered that a complete coverage of all work with full references would be impossible in the future. Dr. Bappu said that he would prefer to make the next Report a critical review of outstanding work and trends, with only a limited bibliography, but some members of the Commission considered the full reference list to be valuable, even if only a limited text were possible. The new President and Committee undertook to consider the matter further.

IV. WORKING GROUP ON ECLIPSES

The Working Group (G. Newkirk) reported as follows: "Since the last General Assembly the Working Group (1 member) has restricted its activities to placing parties interested in observing the total eclipses of June 1974 and October 1976 in direct contact with Mr. A. Driver (CSIRO), Australian Coordinator, and Mr. R. La Count (NSF).

The Group recommends that it should continue in existence so as to facilitate contact between scientists and coordinators in the countries involved in future eclipses."

The Commission expressed its gratitude to the eclipse coordinators for their efforts on behalf of the astronomical community. G. Newkirk agreed to continue as head of the Working Group.

V. SYMPOSIA

The Commission agreed that it would be timely to hold a symposium in 1979 dealing with stellar chromospheres ("what have we learned in the past 25 years") and their relation to the solar chromosphere.

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It was also suggested that a suitable topic for a future symposium would be "small scale velocity fields and the interpretation of line profiles."

VI. RESOLUTIONS

The Commission supported unanimously the following resolution by Commission 14: "The International Astronomical Union rates highly the activities of the United States National Bureau of Standards in the compilation and critical evaluation of atomic and molecular data, and considers these activities essential to the advancement of astronomy."

VII. FUTURE OF THE SOLAR COMMISSIONS

The Commission agreed to a proposal by G. Newkirk, President of Commission 10, that a joint Working Group be established to discuss the possible amalgamation of Commissions 10 and 12. The Working Group will make its recommendations at the next General Assembly.

Scientific Sessions

The scientific sessions took the form of symposia on selected subjects of current interest, several being joint meetings with other Commissions. In general, the discussions were based on some 2-4 invited talks, with some very short presentations restricted to the subject matter of the symposium. On the whole the meetings were extremely successful, though there was a good deal of support for one session to be devoted to general papers during the next Assembly.

Two half-day sessions were held jointly with Commissions 10 and 35 on "Stellar and Solar Structure," the first on magnetic fields, dynamics and convection, the second on large-scale motions and oscillations. An account of these sessions appears in the Commission 35 report.

A Joint Discussion on "Small-Scale Structure of Solar Magnetic Fields" is described in Highlights of Astronomy.

A full day was devoted to "The Interpretation of Atmospheric Structure in the Presence of Inhomogeneities." A. Skumanich discussed multi-dimensional geometrical radiative transfer effects in spectral line formation. U. Frisch detailed the difficulties involved in incorporating "microturbulence" into a physically realistic study of line formation. F. Kneer followed by reviewing the radiative transfer calculations which have attempted to infer the macroscopic velocity field structure of the solar atmosphere. R. F. Stein emphasized briefly the importance of solving simultaneously the radiative transfer equation coupled to the pertinent aerodynamics. A. Omont discussed the problems encountered in atomic physics which limit our understanding of the redistribution function. R. W. Milkey then presented the radiative transfer effects due to angle and frequency redistribution at a photon scattering event. R. G. Athay discussed the types of observations and diagnostic analyses one can make which enable the structure of the solar atmosphere to be determined better. Emphasis was placed on the need for simultaneous observations of several spectral lines. R. G. Giovanelli emphasized the strong time-dependence of the inhomogeneities involved by presenting a movie of the solar atmosphere taken simultaneously in CaK and Hα.

A further full-day session was devoted jointly with Commissions 10 and 34 to a "Report on Skylab and OSO-8". This is described in the Commission 10 report.

A joint meeting on "Advances in High Spectral and Spatial Resolution" was held under the sponsorship of Commissions 9 and 12. S. P. Worden, Sacramento Peak Observatory, spoke on solar and stellar speckle interferometry. Speckle technique was reviewed and new observations were given on umbral dots, indicating that their

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size is approximately 1/4 arc-sec. P. Lena, Meudon Observatory, described a successful attempt to resolve IR sources using speckle at 2.0 μm wavelengths; the seeing-disk of the 4-m Mayall telescope was rapidly scanned by a slit aperture. J. Brault, Kitt Peak National Observatory, summarized the advantages of Fourier transform spectroscopy for visible wavelengths. He stressed that even for the same resolution figure as a grating instrument, the resulting FTS line profile is considerably freer of scattered light and instrumental smear effects. First results with the KPNO 1-m FTS system for spot spectra were presented.

J. Ring gave a progress report on the Imperial College visible light FTS instrument, which is in use for stellar observations with the Isaac Newton telescope. Finally, F. L. Deubner and W. Mattig showed a movie of solar granulation taken on the spectrostratoscope balloon flight in 1975. The extended time of good seeing obtained from the stratosphere platform enabled one clearly to see "exploding" granules, a phenomenon which they demonstrated to be a common occurrence.

Session on Solar Abundances, 1 September 1976.

A session on solar abundances, organized and chaired by E. A. Müller, resulted in a new composite list of photospheric abundances (Table I) which can serve as a standard reference, together with abundances in the corona (Table II) and the solar wind (Tables III, IV).

The session was divided into three parts dealing with these regions separately. Most time was devoted to photospheric abundances, where different groups of elements were discussed separately. The grouping of the elements was made according to common problems characteristic to the determination of their abundances. It was encouraged to include in the discussion the results from sunspot spectra, molecular bands, chromospheric lines, prominence lines, as well as isotopic ratios, if known.

Summaries of the various reports are given below and in Table I are listed the recommended values of the elemental abundances. The photospheric abundances are given on the standard scale log ε (H) = 12.00. Uncertainties are included if they are given by the authors.

It should be noted that while the plans for this session were in progress, three compilations of solar abundances both for the photosphere and the corona appeared in the literature, or are ready to be published, namely Hauge, O. and Engvold, O. (1976, in press); Ross, J. E. and Aller, L. H. (1976, Science 191, 1223); and Withbroe, G. L. (1976, Solar Physics, in press).

I. PHOTOSPHERIC ABUNDANCES

Y. CHMIELEWSKI, (Observatoire de Genève): "The Abundances of the Light Elements, He, Li, Be, and B".

The common characteristics in the determination of the light elements (He through B) are the following:

(1) These elements are represented in the solar spectrum by only very few lines which are usually the resonance lines and which, in most instances, are more or less seriously blended. This fact requires in all cases an abundance determination by the method of spectral synthesis. The number of observational constraints can be increased adequately by using center-to-limb observations which (a) help disentangle the blends, and (b) provide a powerful check on the relevance of the physics used in the derivation of the abundances. The effects of blending and the possibility of departures from LTE, especially in the ionization equilibria, have to be carefully investigated.

(2) The atomic structure of these elements is simple thus giving the advantage that non-LTE calculations can be performed with model atoms that are at the same time simple and realistic. Generally, good f-values and reasonably accurate cross-sections are available.

(3) The lines being faint or of only moderate strength, the computation of their line profiles is not much affected by uncertainties in the damping parameters. Moreover, inasmuch as these elements are very light, thermal broadening dominates and the resulting abundances are relatively insensitive to microturbulence.

HELIUM is somewhat different from the other light elements since its lines can only be observed in the upper chromosphere or in prominences. The results of Hirayama (1971) are in agreement with some of the cosmic ray and solar wind data. A detailed study of the photospheric LITHIUM feature at λ6707.8A (Brault and Müller, 1975; Müller et al. 1975) yielded an abundance similar to that of GMA. The photospheric and the recent sunspot results (Stellmacher and Wiehr, 1971) are in agreement. A thorough re-investigation of the BERYLLIUM lines (Chmielewski et al.,1975) led to no appreciable change in the Be abundance value because the effects due to the additional continuous opacity in the region λ 3000 - 4000 A compensate the non-LTE effects on the ionization equilibrium. BORON has been definitely identified in the solar spectrum by Kohl et al. (1976) who give an abundance result which is no longer an upper limit. ISOTOPIC RATIOS have been reported for H (Beckers, 1975), He (Hall 1975), and Li (Müller et al., 1975) as follows:

$^2H/^1H < 2.5 \times 10^{-7}$, $^3He/^4He = (4 \pm 2) \times 10^{-4}$, $^6Li/^7Li \lesssim 0.01$.

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Hall, D.N.B., 1975: Astrophys. J. 197, 509.
Hirayama, T. 1971: Solar Phys. 19, 384.
Kohl, J.L., Parkinson, W.H., and Withbroe, G.L., 1976: submitted to Astrophys. J.
Müller, E.A., Peytremann, E. and de la Reza, R., 1975: Solar Phys. 41, 53.
Stellmacher, G., and Wiehr, E., 1971: Solar Phys. 21, 97.

D. L. LAMBERT (University of Texas): "The photospheric C, N, and O abundances".

Improved C, N, and O abundances have been derived from the most reliable atomic and molecular indicators. Five model solar atmospheres have been examined, tests against continuum observations showing two of them to be superior. These are the model given by Holweger and Müller, (1974) and an unpublished model by R. Allen. Atomic and molecular lines give consistent abundances when analysed with either model. Other models (e.g. the Harvard-Smithsonian reference atmosphere) do not provide such consistency.

Primary abundance indicators are recognized. They are the [CI] 8727 A line, the CH A-X system, the C_2 Swan bands, the NI lines and the [OI] 6300 and 6363 A lines. These provide the recommended abundances listed in Table I. An uncertainty of ± 0.10 dex is suggested and includes possible NLTE effects and the neglect of the granulation. (This paper will be submitted for publication in Monthly Notices of the Royal Astronomical Society).

References

Holweger, H. and Müller, E.A., 1974: Solar Phys. 39, 19.

D. L. LAMBERT (University of Texas):"Photospheric Abundances: Sodium through Calcium."

An interim revision of photospheric abundances for elements with atomic numbers from sodium through to calcium was presented. Attention was drawn to critical improvements and deficiencies in the f-values. A comparison with meteoritic abundan-

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ces shows excellent agreement (to ± 0.1 dex) except for chlorine (volatile in meteorites) and argon (undetectable in the photospheric spectrum).

SODIUM. The reference analysis is Holweger's (1971). Recent pumping experiments involving two dye lasers give radiative lifetimes in excellent agreement with the coulomb approximation f-values used in the solar analyses. Independent discussions of the NaD line wings (Blackwell et al., 1972;Worral, 1973) used the refined line broadening calculations of Lewis et al., (1971) and obtained an abundance consistent with the value given in Table I, derived from 8 weak lines.

MAGNESIUM. The abundance is most reliably extracted from MgII lines for which the f-values (MgII is isoelectronic with NaI) are reliable. Many weak lines of MgI are available but the presence of severe configuration interaction renders a simple theoretical calculation of the f-values uncertain. Recently, Froese Fischer,(1975), has published results of a MCHF calculation. These provide f-values for 21 weak solar lines and an abundance $\log \varepsilon$ (Mg) = 7.60 ± 0.20 which is consistent with the MgII analysis. The large rms error is attributed to the f-values.

ALUMINIUM. The abundance is not very well determined. Although good lines exist, the theoretical f-values are often uncertain owing to severe cancellation in the radial integral. Other lines are strongly broadened and the line broadening coefficients are uncertain. There are no measurements of f-values for lines in the solar line list; one may anticipate that lifetime measurements by pulsed dye lasers will be reported shortly. The present abundance is taken from Lambert and Warner (1968).

SILICON. The abundance is based on the discussion by Holweger, (1973) who used weak lines with measured f-values. His line list did not overlap with that of Lambert and Warner, (1968), who selected lines with reliable theoretical f-values. When the two line lists are compared for a common model atmosphere, the Si abundances are consistent.

PHOSPHORUS. About 10 weak PI lines from the 4s-4p array and theoretical f-values provide the abundance listed in Table I.

SULPHUR. The abundance comes from a recalculation using a sample of weak SI lines (see Lambert and Warner, 1968) and the forbidden lines λ7725 and λ10821 (see Swings et al., 1969).

CHLORINE. The abundance is provided by Hall and Noyes, (1969), who identified HCl vibration-rotation lines in infrared sunspot spectra.

ARGON. No photospheric lines.

POTASSIUM. The abundance is based upon the resonance lines (a NLTE analysis is reported by de la Reza and Müller, (1975), and about 6 weak excited lines. The coulomb approximation f-values (except for cases of severe cancellation) are confirmed by several accurate measurements.

CALCIUM. The reference analysis is Holweger's (1972). The Ca abundance can be derived from the CaI intercombination resonance transition at 6572 A, weak excited CaI lines, the CaI autoionizing transitions, the [CaII] lines at 7323 A and weak excited CaII lines. The most reliable indicators are the [CaII] and CaII lines. The CaI lines give a consistent result and this sets a good limit on possible departures from LTE in the Ca-Ca^+ ionization equilibrium.

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N. GREVESSE (Institut d'Astrophysique, Université de Liège):
"The Iron Group Elements (Sc through Ni)".

Between 1960 (when Goldberg, Müller and Aller, 1960 (GMA), published their detailed analysis of the abundances of the elements in the solar photosphere) and 1969 a great number of new determinations of the photospheric abundances of these elements were published. Although using more refined techniques, now applicable because of the rapid evolution of the computational facilities, using new solar data, i.e. equivalent widths and profiles, of better quality, and using new extensive sets of transition probabilities, mainly issued from the National Bureau of Standards, the new results confirmed GMA's values.

The old iron abundance problem has disappeared completely. When one compared photospheric values with those obtained from meteorites or the corona, the photospheric iron abundance (GMA) was systematically lower, by a factor of 10, than the others. Other members of the iron group showed similar but smaller discrepancies.

The explanation appeared in 1969; the differences are not real but are due only to systematic errors in the transition probabilities used to derive abundances. In the last 7 years many papers have been published relating either to oscillator strengths of iron-group elements or to revisions of solar abundances of these elements. Special efforts have been made by the spectroscopy groups at Aarhus, AFCRL, Caltech, Harvard, Kiel, NBS, Oxford and elsewhere to determine these oscillator strengths using refined modern techniques. We shall look at the case of iron in some detail, and then pass through the other elements rather rapidly.

Since 1969, when it was shown for the first time by Garz and Koch (1969) that the absolute scale of the available gf-values for Fe I was in error by a factor of $\sim$ 10, 25 papers giving new gf-values for Fe I and Fe II lines have been published. At first some disagreement persisted between absolute scales proposed by different laboratories. More recent results, such as those of Bridges and Kornblith (1974), May, Richter and Wichelmann (1974) and the Oxford group (Blackwell et al., 1975), show an agreement which is within 0.10 dex in the log gf (in many cases the agreement is even better), but minor discrepancies remain to be explained, especially for faint lines. From these new sets of transition probabilities, new solar photospheric abundances have been derived and it is rather surprizing to see that the results appear to scatter from $\sim$ 7.0 to $\sim$7.65. Most of the scatter can be reduced if one uses faint lines for which the gf-values have been measured recently. Thus, most of the scatter in the results is probably due to uncertainties in microturbulence and damping. For this reason we shall retain from among the recent results only those based on faint lines. They are all in agreement with a rather high iron abundance. The recommended value is A_{Fe} = 7.50. It takes into account the above-mentioned results and the result J.P. Swings and myself obtained in 1969 (Grevesse and Swings, 1969) from a study of forbidden Fe II lines whose transition probabilities are known with high accuracy.

Let us now turn to the other elements. As we have already said, they did not attract the same attention as iron. Nevertheless, new sets of gf-values have been obtained during recent years and, for most of them, the initial discrepancy photosphere - meteorites was explained and removed. The adopted photospheric values of the iron group elements are given in Table I; they are in excellent agreement with the meteoritic results.

In concluding I wish to make the following remarks and suggestions:

(1) The techniques used to measure transition probabilites are long, expensive and time consuming. But, we still need a lot of accurate transition probabilities for lines of neutral and, particularly, once-ionized iron group elements. As these measurements are difficult, even extremely difficult for faint lines which are those we need for abundance determinations, we suggest that theoreticians help us to supply the data we need. Biémont (1974) and Huber and Sandeman (1976) have shown that relatively accurate transition probabilities can be computed using semi-empirical methods for neutral iron group elements.

(2) With a few rare exceptions all the photospheric abundances rely upon high quality spectra obtained at the center of the disk. It would be extremely inte-

resting to base the determinations on high quality spectra going from the center up to the limb ($\cos\theta \simeq 0.1$). We hope that Brault's interferometer at Kitt Peak will fill this gap soon.

(3) All the results quoted here were obtained under the assumption of local thermodynamic equilibrium (L.T.E). Athay and Lites (1972) have investigated the effects of departure from L.T.E. on a number of iron lines. They showed that low excitation levels (χ_{exc} < 2.5 eV) are underpopulated by a factor 3 in the high layers where the cores of the lines originating from these levels are formed. But Holweger (1973) and Smith (1974) showed that these departures are extremely sensitive to the collisional cross-sections used and that the non-LTE effects on the abundances are very small (an increase of the abundance of 0.03 to 0.04 dex). Furthermore, no variation in abundance is found when going from the neutral to the once-ionized element, or when examining the abundances derived from lines originating in quite different levels of excitation potential. Therefore, non-LTE effects may be neglected as far as the iron group elements in the solar photosphere are concerned.

(4) Recent work by Carrol et al. (1976) on Fe H, Cr H, and Mn H suggests that Fe H could be present in the spectra of the photosphere and of sunspots, thus opening a new field for abundance determinations of these elements. On the basis of their statistical analysis the temptation is great to conclude on their presence, but complete analyses of these complex spectra is needed before the question can be settled.

(5) Extensive abundance determinations of the iron group elements in sunspots have not yet been performed. The only result I know of is that of Van Paradijs (1975) who made a curve of growth analysis of one sunspot spectrum and obtained A (Fe) = 7.45 ± 0.32. In prominences, the abundances of Sc, Ti and Fe have been determined recently by Yakovkin et al. (1975). Their results, A (Sc) = 3.2, A (Ti) = 4.94 and A (Fe) = 7.40 also agree with the recent photospheric results.

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TABLE I. - ELEMENTAL ABUNDANCES IN THE PHOTOSPHERE

Z.	El.	Log A	Z.	El.	Log A	Z.	El.	Log A
1	H	12.0	26	Fe	7.5	59	Pr	0.8
2	He	10.8 ± 0.1	27	Co	5.0	60	Nd	1.2
3	Li	1.0 ± 0.1	28	Ni	6.3	62	Sm	0.7
4	Be	1.15 ± 0.20	29	Cu	4.2	63	Eu	0.7
5	B	2.6 ± 0.3	30	Zn	4.4	64	Gd	1.1
6	C	8.67 ± 0.10	31	Ga	2.8	66	Dy	1.1
7	N	7.96 ± 0.10	32	Ge	3.4	68	Er	0.8
8	O	8.90 ± 0.10	37	Rb	2.6	69	Tm	0.3
9	F	4.56 ± 0.33	38	Sr	2.9	70	Yb	0.8
10	Ne	–	39	Y	2.1	71	Lu	0.8
11	Na	6.29	40	Zr	2.8	72	Hf	0.9
12	Mg	7.56	41	Nb	2.0	74	W	0.8
13	Al	6.40	42	Mo	2.2	75	Re	<- 0.3
14	Si	7.60	44	Ru	1.9	76	Os	0.8
15	P	5.45	45	Rh	1.5	77	Ir	2.2
16	S	7.25	46	Pd	1.5	78	Pt	1.8
17	Cl	5.5	47	Ag	0.9	79	Au	0.1
18	Ar	–	48	Cd	2.0	80	Hg	< 2.1
19	K	5.14 ± 0.10	49	In	1.7	81	Tl	0.9
20	Ca	6.32	50	Sn	2.0	82	Pb	1.9
21	Sc	3.1	51	Sb	1.0	83	Bi	< 1.9
22	Ti	5.0	55	Cs	< 2.1	90	Th	0.2
23	V	4.0	56	Ba	2.1	92	U	< 0.6
24	Cr	5.7	57	La	1.1			
25	Mn	5.4	58	Ce	1.6			

O. HAUGE (Institut of Theoretical Astrophysics, University of Oslo):
"The Abundances of all Elements Heavier than Nickel: Cu through U."

The abundances of these elements are mainly determined from analyses of photospheric spectra. In a few cases sunspot spectra have been studied (In, Cs, Tl). Coronal lines (Cu), chromospheric lines (Sr, Ba) and prominence lines (Sr, Ba) have also been used.

Abundances published by different authors are commonly in good agreement, particularly for elements present in the photospheric spectrum with lines of medium strength. When studying strong lines, saturation effects and damping may make the derived result more uncertain. In strong lines the contribution to a line comes from higher levels in the solar atmosphere where different atmospheric models are in some disagreement. When faint lines are studied, the derived abundance depend critically on the setting of the continuum level.

Abundances are mostly derived on the assumption of LTE; non-LTE calculations should surely be undertaken, particularly when resonance lines are studied.

The oscillator strengths of lines from some elements are supposed to be well known. Independent determinations undertaken with different methods give results in close agreement. But for many elements, particularly among the RE's, the amount of data is very limited.

Many authors have recently given valuable contributions to the solar abundance table. Here we only refer to the work of two groups. J.E. Ross and L.H. Aller have recalculated photospheric abundances for a large number of elements using improved f-values and subsequently used the HSRA model atmosphere in order to put the determinations in a more uniform system. T. Andersen and his group in Aarhus have succeeded in measuring life-times by beam-foil techniques of energy levels of 11 heavy elements where new f-values were very desirable. These investigations have resulted in a revision of solar abundances by up to a factor of 10 (as in the case of Sm and W). The recommended abundance values are listed in Table I.

II. THE CORONAL ABUNDANCES

CAROLE JORDAN (Department of Theoretical Physics, University of Oxford)

The present summary gives a critically-evaluated list of abundances derived from EUV emission lines formed in the transition region and inner corona. Abundances derived from X-ray spectra present rather different problems and have been recently discussed by Parkinson (1976).

Early analyses of EUV spectra used whole-sun intensities and simple approximations regarding the region of line formation and the relative populations of levels in the ground term and in metastable terms. Also, improved excitation cross-sections have become available. The early work therefore has not been included although it would be possible to re-analyse some of the data.

The abundances given in Table II result from analyses from spectra of regions of the quiet sun (Burton et al. 1971, Dupree, 1972), and a whole sun spectrum in the far EUV (Malinovsky and Heroux, 1973) since quiet sun spectra are not yet published for this spectral region. Some re-analysis of the data published by the above authors has been made. In particular iteration of the region of line formation has been performed, and the writer's choice of atomic data has been used.

The following comments can be made regarding the abundances given in Table I. The high abundance of carbon relative to oxygen given by Withbroe for the EUV lines is weighted heavily by early analyses and is not, in the writer's opinion, borne out by later more sophisticated treatments. The oxygen abundance is not well determined from EUV data, since the lines lie in a region where the shape of the emission-measure distribution is changing rapidly with temperature. The neon to magnesium ratio from EUV lines is between 1 and 2, rather than neon being less abundant than magnesium. Silicon is taken as standard at 7.65 for the present work.

Withbroe's tabulations show a systematic difference in the abundance of iron as determined from EUV lines and visible region forbidden lines. This is not, however, a systematic difference between heights or regions in the solar atmosphere. The writer considers that the difference could lie in a current underestimate of populations of metastable levels in the iron ions.

TABLE II. - ELEMENTAL ABUNDANCES IN THE CORONA

Element	Photosphere	EUV	EUV
	(Withbroe, 1976)	(Withbroe 1976)	(This work)
C	8.54	8.76	8.44
N	8.06	8.08	7.81
O	8.84	8.63	8.84
Ne	-	7.60	7.95
Mg	7.54	7.65	7.75
Si	7.65	7.67	7.65
S	7.21	7.21	7.11
Fe	7.48	7.72	7.65
Ni	6.28	6.45	6.25

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III. ELEMENTAL ABUNDANCES IN THE SOLAR WIND

PETER BOCHSLER and JOHANNES GEISS (Physikalisches Institut, Universität Bern)

1. Introduction

So far, three essentially-different methods have been used for investigating abundances in the solar wind:

- Energy/charge spectrometers have been used for abundances of several elements in times of low solar wind temperature;
- The foil collection technique has provided data on isotopic and elemental abundances of He, Ne and Ar;
- Trapped solar wind gases in lunar soil (and meteorites) have given information on the isotopic composition of several additional elements (H, C, N, Kr, Xe). In addition, some general limits on the abundances of these elements in the solar wind can be derived.

The observed time variations in the solar wind composition indicate that fractionation occurs in the source region and that average solar wind abundances do not have to be identical with photospheric abundances. Some models have been

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developed about ion fractionation in the solar wind acceleration region, but there exists no theory yet which would allow a straightforward calculation of photospheric abundances from solar wind abundances. However, average solar wind abundances are seen to agree with photospheric abundances within a factor of about two, even for elements with very different characteristics such as ionization potential, mass or mass/charge. Therefore, it is concluded that the relative abundances of isotopes in the solar wind are a good approximation to photospheric abundances.

2. Elemental abundances in the solar wind

TABLE III : ELEMENTAL ABUNDANCES IN THE SOLAR WIND.

	Value	Method	Reference
He/H	0.04 ± 0.01	E/Q-Analyzers 1962-1975	Ogilvie and Hirshberg (1974)
O/H	$(5 \pm 2) \cdot 10^{-4}$	E/Q-Analyzers 1969-1972	Bame et al. (1975)
Fe/H	$(5 \pm 3) \cdot 10^{-5}$	E/Q-Analyzers 1969-1972	Grünwaldt (1976)
Si/H	$(7.6 \pm 3) \cdot 10^{-5}$	E/Q-Analyzers 1969-1972	Bame et al. (1975)
He/Ne	530 ± 70	Foil collection 1969-1972	Geiss et al. (1972)
Ne/Ar	41 ± 10	Foil collection 1969-1972	Cerutti (1974)

Comments: The He/H ratio is varying with time. Ogilvie and Hirshberg (1974) have reviewed values measured during a whole solar cycle and discussed correlations of this ratio and its fluctuation with the velocity of the solar wind, phase in the solar cycle, temperature etc. The value of 0.04 is a good average of He/H in the solar wind over a whole solar cycle but it is most probably lower than the value in the source region. The Los Alamos group (Bame et al., 1975) has published O/H, Si/H and Fe/H ratios in the solar wind for several selected periods from 1969 to 1971. The authors judge the experimental errors of their results to be approximately a factor of two. Grünwaldt (1976) has given the average O/H and Fe/H ratio for a period of two days of exceptionally-quiet solar wind conditions. His values are compatible with those of Bame et al. (1975). He/Ne and Ne/Ar ratios have been obtained by means of the foil collection technique.

The errors in Table III indicate the range of fluctuations in a sample which is not complete. Therefore the true elemental ratios in the solar wind could in a few cases be beyond the given limits of error.

Investigations in the lunar soil have shown that krypton and xenon are present in the solar wind, but due to the unknown trapping and storing conditions it is difficult to give reliable abundance values. The same holds for C and N. The C/N ratio in the trapped gas is 1.5 (Kerridge, 1975).

A comparison of the solar wind abundance values given in Table III with spectroscopic data shows that the deviations are not larger than a factor of about two.

3. Isotopic abundances

Comments: No deuterium has been found in solar wind trapped in lunar soil. The given upper limit is determined by the contamination of lunar fines with terrestrial hydrogen and by spallation-produced deuterium.

The $^4He/^3He$ ratio fluctuates in the solar wind (Bame et al., 1975; Geiss et al., 1972; Grünwaldt, 1976) reflecting fractionation processes in the corona. Therefore, the average solar wind ratio given above could be lower than the ratio in the outer convective zone, perhaps by as much as 10 to 30 %.

The isotopic composition of solar neon is significantly different from terrestrial neon, while no deviation is found between the solar and the terrestrial $^{36}Ar/^{38}Ar$ ratio.

Trapped solar wind carbon has within the limits of errors the same isotopic composition as terrestrial carbonates. Nitrogen behaves strangely: There are strong variations observed in lunar fines and there is an indication that the nitrogen composition in the solar wind has been changing with time.

Solar wind krypton is only slightly fractionated relative to terrestrial krypton. Xenon, however, is linearly fractionated relative to terrestrial atmospheric xenon with a fractionation factor of 3.6 % per mass unit, the heavier isotopes being depleted. Furthermore, it appears that in terrestrial xenon a component rich in the lightest and heaviest isotopes is slightly depleted (Lewis et al., 1976). Terrestrial xenon has been augmented by ^{129}Xe from the decay of ^{129}I taking place after the gas-grain separation in the planetary nebula.

TABLE IV : ISOTOPIC ABUNDANCES IN THE SOLAR WIND.

	Value	Method	Reference
D/H	$< 3 \cdot 10^{-6}$	Lunar soil	Epstein and Taylor (1972)
$^4He/^3He$	2350 ± 120	Foil collection	Geiss et al. (1972)
$^{20}Ne/^{22}Ne$	13.7 ± 0.3	Foil collection	Filleux et al. (1977)
$^{22}Ne/^{21}Ne$	31 ± 4	Foil collection	
$^{36}Ar/^{38}Ar$	5.3 ± 0.3	Foil collection	Cerutti (1974)
	5.33 ± 0.03	Lunar Soil	Eberhardt et al. (1972)
C	(1.5 ± 1.5) % $\delta\, ^{13}C$	Lunar Soil	Epstein and Taylor (1972)
N	(3 ± 7) % $\delta\, ^{15}N$	Lunar Soil	Kerridge (1975)

4. Conclusions

The importance of the investigation of abundances in the solar wind lies in the unique possibility to obtain precise values on the isotopic composition of some elements in the outer convective zone of the sun. These data are relevant for the understanding of the history of the solar system and the universe; they are placing limits on models for the synthesis of elements.

It is yet difficult to derive precise solar element abundances from solar-wind measurements because of the fractionation processes in the corona. However, the noble-gas data from the solar wind provide even now some valuable evidence on elemental abundances in the sun.

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COMMISSION 14: FUNDAMENTAL SPECTROSCOPIC DATA (DONNÉES SPECTROSCOPIQUES FONDAMENTALES)

Report of Meeting, 25 August 1976

PRESIDENT: R. H. Garstang

The President thanked the Chairmen of the Working Groups for their part in the preparation of the Report of the Commission.

Membership of the Commission. The President reported the deaths of four members of the Commission (W. R. Hindmarsh, T. A. Littlefield, B. Rosen and E. W. Salpeter), the replacement of L. J. Kieffer by E. C. Beaty as a Consultant and the nomination of I. Martinson as Consultant. He reported the nomination of E. Trefftz as President and J. G. Phillips as Vice President for the next three years. R. H. Garstang, W. Lochte-Holtgreven, S. L. Mandelsh'tam, A. H. Gabriel, R. W. Nicholls, S. Sahal and W. L. Weise were elected as the Organizing Committee for 1976-1979.

There was a brief discussion of the Report of the Commission. Concern was expressed on the limited distribution which the Report receives in relation to the work involved in its preparation.

Resolution. It was moved by M. J. Seaton, seconded by A. H. Cook, and after minor amendments, carried unanimously, that "The International Astronomical Union highly values the activities of the United States National Bureau of Standards in the compilation and critical evaluation of atomic and molecular data, and considers these activities essential for the advancement of astronomy." (Following the meeting the President obtained the agreement of Commissions 12 and 29 to co-sponsor the Resolution for submission to the General Assembly.)

The President presented a brief report by K. M. Baird supplementing his printed Report. Much work is in progress on extending frequency measurements to the visible part of the spectrum. There seem to be many alternatives more accurate than the present caesium standard but much remains to be done before a practical alternative can be proven. However, it should soon be practical to redefine the meter in terms of the caesium frequency standard and the adopted value of the velocity of the light. There have been new measurements by G. Guelachvili of 87 absolute wave numbers in $HC\ell$ and HF spectra and by C. Freed and co-workers of absolute frequency values for a very large number of transitions in CO_2 isotope lasers.

The President reported work by G. H. C. Freeman (Consultant to the Commission), who now has a Michelson interferometer in the vacuum ultraviolet. Problems of polishing and coating of magnesium fluoride discs have been overcome. The interferometer is being used to study the shape of the Xe I 147 nm line under conditions where the width of the line is less than 500 fm as a prelude to measuring its wavelength.

W. Huebner reported on his opacity library, set up so that the user can obtain opacities of mixtures of his choice.

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Report of Meeting, 26 August 1976

PRESIDENT: R. H. Garstang SECRETARY: M. C. E. Huber

ATOMIC DATA FOR ASTROPHYSICS

W. C. Martin presented information supplementing the Commission Report. He referred to Edlén's recent review (Beam Foil Spectroscopy, Eds., I. A. Sellin and D. J. Pegg, Plenum, New York, 1976, Vol. 1, p. 1) which has a bibliography of 300 references on the spectra of atoms from helium to nickel. A new NBS bibliography will be published soon (L. Hagan, NBS Special Publication 363, Supplement 1, 1976) covering July 1971 to June 1975. A compilation on Cr I to Cr XXIV will be published in 1977 (J. Sugar and C. H. Corliss, J. Phys. Chem. Ref. Data) and work on a compilation for manganese is in progress. A compilation on O I is now available (C. E. Moore, NSRDS-NBS 3, Section 7, 1976). Reports from several laboratories were received too late or were unintentionally omitted from the list in the Draft Report. Perhaps of most direct astronomical interest in this regard is work on Fe X-XIII and Fe XVIII-XXIII in the Astrophysics Research Div., Culham Laboratory, Abingdon, Oxon, England (reported by B. C. Fawcett). Space does not permit giving detailed references to individual papers which have been published.

K. Widing presented a paper by C. Moore-Sitterly and himself, in which they reported that extensions of known C I series account for many lines in solar limb and flare spectra. Over 300 additional lines of Si I have also been identified in limb spectra. Further laboratory studies on Fe I, Sn I and Pb I spectra are in progress and work on Ge I has been completed. G. D. Sandlin has prepared a list of 100 forbidden lines in the solar corona and transition zone in the ultraviolet.

M. J. Seaton spoke on progress and prospects in the computer calculations of atomic data. He drew attention to very general computer programs which have been developed at Queen's University Belfast (QUB) and at University College London (UCL). These programs are in use at a number of other institutes. Other groups active in the calculation of atomic data include those at ETH Zurich, Observatoire de Paris (Meudon); Observatoire de Nice; University of Maryland; Goddard Space Flight Center; Lebedev Institute (Moscow); Leningrad State University; Louisiana State University; JILA, Boulder, Colorado; IBM, San Jose, California; MPI Munich; Physics Institute, Riga, Latvia. Data calculated include atomic structures and energy levels, radiative transition data (bound-bound, bound-free and free-free) and cross sections for electron collisions with atoms and ions. The most accurate formulation of the collision problem is "close-coupling plus correlation terms" (CC + CT). The groups at QUB and UCL have shown that this formulation also provides a powerful technique for the calculation of radiative data. The distorted wave (DW) and Coulomb-Born (CB) methods are less accurate but are economic in computing resonances and should be satisfactory for electron collisions with more highly ionized systems. However, in some cases the errors in DW calculations turn out to be larger than might have been expected -- for example, in the 2s-2p transition in N V the error is nearly a factor of two (due to strong coupling between the $n = 3$ states).

Seaton mentioned the accurate measurements recently made for 1s-2s and 1s-2p excitation in H (J. F. Williams): the results are in excellent agreement with (CC + CT) calculations. For the isoelectronic case of He^+ 1s-2s, there is however, a puzzling disagreement between calculations and experiment. Sophisticated calculations for Be^+ 2s-2p give results about 15% larger than those of recent measurements; the difference may be within the accuracy of the absolute calibration of the experiment. The QUB and UCL groups have made (CC + CT) calculations for excitation of atoms and ions with outer $2p^q$ electrons.

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Although there is little direct comparison experimental data, consistency checks suggest that the calculated results are correct to within about 5%. Calculated photodetachment cross sections for alkali negative ions are in good agreement with measurements made using lasers. Accurate photoionization cross sections have been calculated for Be, Mg, C, N, O, Ne and Aℓ. Similar techniques have been used to calculate large numbers of f values for O I and Mg I. In summary one can say that (i) good progress has been made for systems up to Ne in the periodic table, (ii) similar work for systems up to Ca should be possible with existing techniques, (iii) for heavier systems some work is being attempted but real progress may require the use of new-generation computers and (iv) for highly ionized systems the DW and DB methods can be used but further work is required to establish the exact range of validity of these approximations.

Replying to A. Dalgarno, Seaton said that it was difficult with present techniques to calculate cross sections for simultaneous ionization and excitation. He also pointed out that difficulties may arise in calculations involving highly excited states, because, there, one ought to consider the coupling with many states. A. Burgess commented that ionization cross sections calculated by the Exchange Classical Impact Parameter method agree quite well with plasma measurements, in fact, better than the results obtained with Coulomb-Born calculations.

Presenting a review by himself and D. R. Flower, H. Nussbaumer remarked that the calculation of ionization rates is at present in an uneasy situation in that the Coulomb-Born calculations disagree with the Exchange Classical Impact Parameter (ECIP) method. While satisfactory agreement between the Coulomb-Born calculations and crossed electron-ion beam experiments is found at high energies, the astrophysically important region is mostly that close to threshold. It appears that close to threshold the Coulomb-Born method rather systematically overestimates the cross sections. Statistically the crossed beam experiments are better represented by the ECIP method, however, the individual error bars are rather large. Ionization cross sections deduced from time dependent plasma experiments seem to favour the ECIP results. In a review on dielectronic recombination theory just completed, Seaton and Storey find that Burgess's general formula for recombination is usually accurate to better than 30%. The best available method for calculating collision strengths is now the Close Coupling method (CC). One expects the Distorted Wave method (DW) to be applicable to ionized systems with accuracy increasing with the degree of ionization and it is much more economical than CC. It is not possible to give safe rules as to when DW may be sufficient and we have to learn from accumulated experience, although it appears that DW works for strong transitions even in lowly ionized systems, as for example in C III. Based on the same bound state functions, collision strengths calculated in the DW approximation and by the CC method agree to better than 10%, even close to threshold. Collision strengths for $2s^2 - 2s3\ell$ transitions are also needed. But we must not conclude that the DW method will be sufficient for these transitions because it was good enough for transitions within the $n = 2$ complex. This reservation is based upon experience gained from N V, where DW and CC collision strengths for $2s - 2p$ and $2s - 3d$ agree well but where they disagree for $2s - 3s$ and $2s - 3p$. The discrepancies are due to collisional coupling between the 3ℓ terms. We may expect similar effects on the less ionized C III. Doing a CC calculation is in itself no guarantee of good results, one also requires a good representation of the bound states. To represent the ground state $2s^2\ ^1S$ in C III one must allow for configuration interaction with $2p^2\ ^1S$. The CC collision strength for the $2s^2\ ^1S - 2s2p\ ^1P$ transition differs by a factor of two between the two-configuration calculation and the result allowing for $2s^2 - 2p^2$ interaction. The same interaction also has an important effect on the $2s^2\ ^1S - 2s2p\ ^3P$ transition probability.

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The collision strengths for that intercombination transition are strongly energy dependent because of the presence of resonances converging on $2s2p\ ^1P^o$. Although the atomic physicist may be interested mostly in the complicated resonance structure, the result needed to interpret observations is the collision strength averaged over the Maxwellian energy distribution. For the solar case the resonance contribution is approximately equal to the direct contribution. Collision strengths for the fine structure transition $2s2p\ ^3P^o_J - ^3P^o_{J'}$ are also strongly influenced by resonance contributions. A further illustration of the need for investigating resonances is the B sequence. For transitions between levels of the configurations $2s^22p$ and $2s2p^2$ the collision strengths for $^2P^o_{1/2} - ^2P^o_{3/2}$, $^2P^o_J - ^4P_{J'}$, $^4P_J - ^4P_{J'}$, $^4P - ^2P$ are expected to show resonance structures resulting in important contributions to the total collision strengths. Spectral lines from the B sequence are of considerable astrophysical interest. The sun provides an example. For the N III λλ991, 686 lines an intensity ratio $I(^2P^o - ^2D)/I(^2P^o - ^2P)$ of about 3 is observed for quiet regions and of about 7 for active regions. Based on DW calculations one finds from the observed ratios $T_e \approx 40000$°K for quiet and $T_e \approx 26000$°K for active regions, thus a lower temperature for active regions. Both these temperatures are considerably below the temperature for which the fractional abundance of N^{+2} attains its maximum value which is approximately 80000°K. This is certainly an interesting result concerning the solar transition region, but should be viewed with caution until the applicability of the DW approximation in this case has been confirmed. Nussbaumer stressed again the importance of resonance contributions to the collision strengths for forbidden and intercombination transitions. An exact treatment of them is laborious, but verifications are needed for various cases to ensure that approximate methods may be employed. Collision strengths for strong transitions in ionized atoms can probably be safely calculated by the DW approximation. To establish the lower ionization limit for the validity of DW one needs a CC calculation for each isoelectronic sequence. Weak transitions to nearly degenerate terms may in any case demand a CC calculation although this may not be feasible in practice.

D. R. Flower cited further support for the accuracy of Nussbaumer's C III data: computations recently made by Hibbert yield a transition probability for the 1908 Å intercombination line that lies within 10% of the value derived by Nussbaumer. In reply to C. Jordan, Nussbaumer confirmed that no close-coupling nor distorted-wave calculations involving more than three configurations have been published for C III. However, the inclusion of 24 rather than three configurations resulted in a change of 8 to 10% for the transition probabilities of the 977 and 1176 Å lines. The collision strengths for these strong transitions might be expected to vary like the oscillator strength; this had, indeed, been confirmed by recent calculations at University College London. Thus, he had confidence in the collision strengths he used, since they had been scaled by comparing oscillator strengths from 3 and 24 configurations. Seaton noted that cross sections for collisions $2s \rightarrow 2p$ of Be^+, calculated in the close-coupling approximation, had changed only 5% if $n = 3$ configurations were included. This makes it probable that the inclusion of $n = 3$ states would make little difference to the C III collision strengths for transitions between $n = 2$ states.

S. Sahal-Bréchot and V. Bommier described a method for determining magnetic fields in solar prominences by use of the Hanle effect in the D_3 line of He (3^3D-2^3P). Radiation in this line is polarized because of its anisotropic radiative excitation from the photosphere. Owing to Zeeman coherences, the degree of polarization and the direction of linear polarization are sensitive to the strength and direction of magnetic fields. Calculations have been made for fields up to 15 Gauss (i.e. in the range that is most sensitive and also free of level crossings). Comparisons between these calculations and solar observations showed that the method is feasible. The determination will be complete when the D_3 line is observed simultaneously with an additional line.

G. Brueckner discussed the need for improved atomic data for the interpretation of the ultraviolet solar spectrum. Improved line identification compilations of high-temperature lines (180-600 Å), $10^6 < T_e < 6 \times 10^6$ are necessary to identify several hundred flare lines in this region which have been detected but remain unidentified. The chromospheric spectrum 1100 to 1800 Å shows approximately 4000 emission lines, of which 2000 still remain unidentified. Many of these mostly weak lines are enhanced in sunspots. From their appearance it is likely that these lines are formed in a temperature regime $4000° < T < 10000°K$. Complete laboratory line lists of Fe I, Mg I, Co I, Cu I, Ni I and Mn I, including high level transitions, are needed. In addition, improved ultraviolet laboratory spectra of the second and third spectra of all elements found in the sun are necessary. From the comparison with the visible chromospheric flash spectrum one would expect ultraviolet lines of the less abundant elements like V I, V II, As I, As II, Sr II, La II, Y II, Ba II, Sc II, Zr II, and Mn II to be present in the sun. Laboratory UV spectra of these elements are needed.

Brueckner then considered the wavelength reference system, which needs vast improvement for all prominent solar lines in the 180 to 1800 Å region. Presently the mean deviation of solar from laboratory wavelength is $\Delta\lambda/\lambda = 8.7 \times 10^{-5}$ for 50 lines in the 274-4100 Å region. In order to carry out meaningful Doppler measurements in the solar spectrum, laboratory standards for the prominent solar lines need to be known with an accuracy of $\Delta\lambda/\lambda = 1 \times 10^{-6}$. This measurement accuracy has been achieved with C I standard lines in the 1274-1459 Å region, but other areas of the 1100 to 1800 Å solar spectrum do not contain enough standard lines. A list of low-temperature, unblended solar lines covering this area of the spectrum has been compiled; approximately half of them need new laboratory wavelength measurements. In addition, standard wavelengths with an accuracy of $\Delta\lambda/\lambda = 10^{-6}$ of the most important transition zone lines in the solar spectrum $1100 < \lambda < 1800$ Å are needed. Brueckner concluded by emphasizing the importance of atomic cross sections and transition probabilities. By using combinations of allowed and spin-forbidden transitions, the ultraviolet solar spectrum has great advantages over the visible spectrum when carrying out refined diagnostic work on the solar chromosphere. Improved electron excitation cross sections, ionization cross sections and f values are needed for C I, Si I, O I, Si II and Fe II, especially for the intersystem lines. Numerous new observations of density-sensitive line ratios in the transition zone have been made recently, using C III, Si III, O IV and O V. Conflicting electron densities result if the presently available atomic parameters are used. The errors of these parameters must be decreased below ±10%. Only then can meaningful density values be derived.

In discussion Seaton pointed out that the identification of transitions involving high-lying states can frequently be hampered by series perturbations. Jordan said that because the intensity ratio of the lines λλ1908 to 1176 was determined at the limb, λ1176 would be expected to be optically thick. This should influence the results derived from the intensity ratio. E. M. Reeves reminded the audience that photoelectric observations had shown considerable variations with time in the intensity of many of the lines used for diagnostics; consequently, time-dependent ionization-equilibrium calculations might be expected to shed more light upon many currently contradictory results. Replying to Garstang, Jordan and A. K. Dupree thought that the variation of N_e and T_e over the region where the C III lines are formed would not explain the C III discrepancy. Nussbaumer reiterated his opinion that the atomic data are now accurate enough to make the C III problem a question of interpretation -- possibly including time dependences -- rather than of atomic data.

In commenting on the oscillator strength section of the Commission 14 Report R. H. Garstang pointed out that references had been given in full only if they did not appear in Astronomy and Astrophysics Abstracts. He also presented some extracts from a report on work in the U.S.S.R. which had been received too late for inclusion in the printed Report. He drew attention to the Russian work on wavelengths and transition probabilities in the hydrogen, helium and lithium isoelectronic sequences, to several important papers on ultraviolet spectroscopy of highly charged ions produced in vacuum spark and laser plasmas, and to lifetime and oscillator strength measurements in many elements. Up-dating his Report, Garstang drew attention to continuing work on improved furnace measurements of Fe I by Blackwell, beam-foil measurements by Andersen and colleagues on ions such as Fe III and Ti III, recent high-accuracy beam-foil lifetime measurements by Curtis and others, combined hook and absorption measurements on Cr I and Ni I by Huber and Sandeman, calculations on O I by Saraph using the frozen-cores approximation, and work by Grant on relativistic intensity calculations.

E. Trefftz commented on her report, and pointed out that many items had been omitted because of lack of space. She drew attention to recent work by E. W. Smith (NBS Boulder) on calculations of molecular line broadening by neutral particles. K. T. Tang worked on $H - H_2$ collisions. The anisotropic part of the potential is now reasonably well established. There are still discrepancies in the collisional calculations. J. Schäfer (MPI Munich) used a carefully calculated potential of $H_2 - H_2$ by W. Meyer (Univ. of Mainz) to do close coupling calculations. He finds large probabilities for the rotational excitation of both H_2 molecules. Chemical reactions are sometimes restricted to head-on collisions. Manz (TU Munich) suggests generalizing a one-dimensional calculation to three dimensions by statistical methods.

J. W. Liebert described his work on the blue white dwarf suspect Feige 7, which has been found to have a rich optical spectrum, and variable circular polarization with a period of 2.2 hours. The mean longitudinal field is estimated to be 5 million Gauss at peak polarization. The spectrum fits Zeeman patterns of hydrogen and He I in the presence of mean homogeneous fields of about 20 million Gauss. The star provides the first confirmation of the theoretical spectra of hydrogen and helium in such high fields, inaccessible to laboratory measurements. The period must be due to rotation, and the blue continuum indicates that it is the hottest of the known magnetic degenerate stars. The comparable intensity of H and He I lines may be unique in white dwarf stars. The star must have a helium dominated atmosphere. Liebert showed spectrophotometric observations of the magnetic stars GD 229, G 240-72 and G 195-19.

G. Wegner remarked that the magnetic field in the peculiar white dwarf BPM 25114, suggested by Bessel and Wickramasinghe, has been confirmed with circular polarization in the hydrogen lines, and $H\gamma$ line profiles indicating a field of 10^7 Gauss.

Report of Meeting, 31 August 1976

PRESIDENT: R. H. Garstang SECRETARY: J. B. Tatum

MOLECULAR DATA FOR ASTROPHYSICS

R. W. Nicholls described some recent work on molecular spectra. For diagnostic applications in astrophysics the principal molecular data needed are (a) wavelengths (for the location of energy levels and transitions between them, (b) intensities (for the determination of transition probability data), and (c) cross sections and rate constants (for the definitive assessment of energetic processes). We have been principally concerned with (a) and (b), contrary to

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popular belief reliable data in both areas for molecules and band systems of astrophysical interest are quite fragmentary. This is clear from a careful assessment of the data compilations (Données Spectroscopiques of Rosen and of Barrow, and more particuarly in Suchard's two recent works Spectroscopic Data I (Heteronuclear Molecules - parts A and B) (Plenum Press, New York, 1975), Spectroscopic Data II (Homonuclear Molecules) (Plenum Press, New York, 1976). Many of the early analyses of molecular spectra were not extensive enough nor were made with sufficient precision to be useful in the high resolution computer synthesis of molecular spectra. The situation is far worse for transition probability data, as indicated in a review chapter on the subject in the 1977 Annual Review of Astronomy and Astrophysics by R. W. Nicholls. Nicholls illustrated his remarks by discussing work in his own laboratory on excitation, wavelength analysis, intensity measurement and theory (including computer simulation) of (mainly diatomic) spectra of astrophysical, aeronomical and atmospheric importance. Molecules currently under study are O_2, C_2, CN, CℓO, ScO, and YO. Examples of work on O_2 and CℓO were presented.

L. E. Snyder reviewed microwave molecular spectra. As of August 1976, 40 molecular species had been identified in the interstellar clouds. The two most complex, dimethyl ether and ethyl alcohol, are isomers with nine atoms each; 29 of the molecules contain one or more carbon atoms, the other 11 contain no carbon atom. The identification of interstellar X-ogen as HCO^+ (formyl ion), suggested by Klemperer, has been confirmed. In 1975 the isotope $H^{13}CO^+$ was found in space and subsequently the group of R. C. Woods reported laboratory measurements of both $H^{12}CO^+$ and $H^{13}CO^+$ which were in excellent agreement with the interstellar measurements. Later Woods' group measured DCO^+ which then was found to have remarkably high intensity in several galactic molecular clouds. The identification work on interstellar HNC (hydrogen isocyanide) has been completed. As a result of a suggestion of G. Herzberg, D. Buhl and Snyder searched for and found HNC in the interstellar clouds. Recently three different laboratory groups were successful in measuring HNC and its isotopes and $HN^{13}C$ was detected in space. Laboratory measurements have confirmed the identification of interstellar N_2H^+. This molecule was discovered accidentally by Turner, tentatively identified by Green et al. on the basis of molecular computations, and measured in the laboratory by Saykally et al.

Snyder surveyed progress on the chemistry of interstellar molecules. Theoretical models utilizing ion-molecule chemical formation schemes have shown HCO^+ to be a keystone molecule for the formation of other interstellar molecules. In agreement with model predictions, observations have shown HCO^+ to be abundant and widespread throughout the galactic molecular clouds and N_2H^+ to be anti-correlated with CO and HCO^+ in Orion. DCO^+ was found to be enhanced in cool clouds in agreement with chemical fractionation models. The dark cloud L134 produced a spectrum of HNC which (a) is of higher resolution than any currently available laboratory spectrum and (b) has approximately the same intensity as HCN. Ion-molecule formation theory predicts that the reaction $H_2CN^+ + e$ forms either HCN + H or HNC + H. Hence the dark cloud L134 may represent the first observed case where the branching ratio (HNC/HCN) is approximately unity. The formyl radical, HCO, has been studied extensively in the laboratory and often advocated as an interstellar molecule. All searches for HCO have been unsuccessful until very recently when the J = 3/2-1/2, F = 2-1 transition at 86,670.65 MHz was found. In agreement with the models of W. D. Langer, the formyl radical was not detected in the densest molecular clouds but rather in clouds which appear to be of intermediate density. The interstellar measurements indicate that typically the number density ratio HCO^+/HCO is 2-5 except for W51 where the ratio is 7-17.

Concluding, Snyder stressed the need for continuing fundamental microwave laboratory measurements on small refractory molecules (such as TiO and VO). On the basis of the discovery of large interstellar molecules he suggested that

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microwave measurements of small optically active molecules could become important for future polarization studies. Unidentified interstellar microwave lines continue to be detected: U86.76 in Sgr B2 interferes with $H^{13}CO^+$ and may be CH_3C_3N (methylcyanoacetylene); U90.146 could be COH^+; and several identified lines were found as the result of observations which began as a search for the gauche isomer of ethyl alcohol. Reaction intermediates such as NH_2^+, CH_3CO^+, H_3CO^+ and H_2CN^+ are important in ion-molecule formation schemes but there is little or nothing known about their microwave spectral properties.

In the ensuing discussion E. Trefftz asked whether there is any explanation of the fractionation of hydrogen and deuterium in the molecules HCO^+ and DCO^+. Snyder replied that the degree of fractionation depends on the electron density, the density of hydrogen molecules and the temperature. The detectability of deuterium is greater at lower temperatures. It is possible that in the dark clouds we are observing a primordial deuterium abundance. Responding to questions by P. K. Carroll and A. Dalgarno, Snyder indicated that metallic hydrides are likely candidates for detection in space, and that it is surprising that OD has not been seen, it would be worthwhile searching for OD again in the dark clouds.

A. H. Delsemme discussed molecules in comets. Until recently only water ice could reasonably be trusted as a major constituent of the volatile fraction of a cometary nucleus. Now for the first time radio astronomical observations of comets have yielded results. They reconfirmed water as a parent molecule. CH_3CN was identified by Ulich and Conklin, HCN by Huebner et al., and several unidentified lines were observed. OH and CH, known in the optical range, were also detected via the splitting of the ground-state doublet. Brightness profiles across the coma yield decay times of the observed molecules and of their unobserved parents. A better knowledge of molecular absorption cross sections for dissociation and ionization in the ultraviolet should allow parent identifications. Pure photochemistry can be observed in the cometary exosphere. Therefore observed large velocities can result from the energy balance of the dissociations and should be used for the identification of parent molecules from their dissociation mechanisms. High-dispersion spectra have confirmed the usual assumption of a small expansion velocity for C_2 and CN. Charge-exchange reactions play a fundamental role in the collisional zone of the inner coma, reshuffling many molecular species; in particular, the role of H_3O^+ must predominate, but its spectrum is unknown. The observation and detailed analysis of a laboratory spectrum of H_2O^+ by Lew and Heiber has led to the first identification of a cometary ion since 1942. The detailed analysis was a prerequisite for predicting the very low temperature spectrum observed in comets.

Delsemme emphasized that with the increasing availability of vacuum UV spectra of comets more complete data are needed on diatomic and polyatomic molecules. The resonance lines of H, C and O have now been repeatedly observed (Comets Kohoutek and West) from satellites and rockets; in Comet West, the first negative system of CO^+, the bands of CS from 2500 to 2700 Å, and CN^+ near 3200 Å have also been observed. Surprisingly, a large production rate of C I in its ^1D state is also mentioned (Feldman et al., and Smith et al.), its origin is unknown yet, although it could probably be a mechanism analogous to the excitation of the red forbidden line of CO_2. In the laboratory, Meinel has obtained C_2^+ in absorption, and Herzberg, probably NH_2^+. Radiative lifetimes of cometary ions and molecules in their excited levels are much in demand. Most oscillator strength data are still poor for the simplest molecules: UV photoabsorption data, including ionization or dissociation rates and collisional excitation cross sections, are still missing or insufficient to compute space lifetimes of most molecules, ions and radicals; more accurate data on the solar flux in the extreme UV are also badly needed to predict the branching ratios of parent molecules into ionized or dissociated fragments.

A. Dalgarno discussed the role of molecular processes in theories of evolution of interstellar clouds, star formation and the star-gas interaction. The main heat loss in a diffuse cloud arises from excitation of the $^2P_{3/2}$ fine structure level of C^+. Collisions of C^+ and H_2 in the zero and first rotational levels require more detailed study. In a dense cloud, rotational excitations of interstellar molecules control the heat loss. Cross sections are needed also for diagnostic purposes. Much progress has been made in developing procedures for the solution of the scattering problem but less progress has been made in developing methods for calculating potential energy surfaces to the chemical accuracy required. Nevertheless due mainly to Sheldon Green, data are available for the atoms colliding with N_2, CO, N_2H^+, HCℓ and H_2CO. The main collision partner however, is H_2 and only limited information is available. Cross sections of collision-induced molecular hyperfine and fine structure occur in theories of astrophysical masers but are available only as arbitrary estimates. Charge transfer of highly stripped ions with atomic hydrogen modifies the ionization structure of a gas ionized by cosmic rays or X-rays. Work has been carried out on the charge transfer of C III, C IV, N III and Si III. Charge transfer with helium also needs exploration. Radiative charge transfer rates have been calculated. Dalgarno drew attention to a major compilation by W. Huntress on ion molecule reactions in interstellar chemistry. Little information is available at temperatures appropriate to interstellar clouds, and in some cases the exothermicity of critical reactions has not been established. Of major significance is the rate coefficient and its temperature dependence for the radiative association of C^+ and H_2. The rate coefficient for C^+ and H has been determined now to be 3×10^{-17} cm^3 sec^{-1} at 100°K. Dissociative recombination of CH^+ is still entirely uncertain as are the branching ratios for polyatomic ions. Photoionization and photodissociation cross sections of interstellar molecules are critical but little progress has been achieved except for the case of OH where an unattenuated interstellar rate of about 10^{-10} s^{-1} seems now to be established.

In discussion B. Zuckerman pointed out that vibrationally excited transitions have been observed in cyanoacetylene, and A. B. Underhill referred to observations of CS in Comet West. In response to a question by Snyder, Dalgarno agreed that probably only about one-fifth of the observed interstellar molecules have so far been understood in terms of ion-molecule reactions; in reply to Trefftz he indicated that H_3O^+ should be observable probably in the infrared or radio regions, but that the triplet transitions of CO would be hard to observe. P. D. Feldman reported that in Comet West the singlet Fourth Positive system of CO was observed but the triplet Cameron bands were not present. The President drew attention to work by R. McCarroll on charge exchange involving multiply charged ions, and by A. J. Sauval on calculations of the molecular equilibrium in cool stars; lack of time prevented detailed presentations of these contributions.

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COMMISSION 15: PHYSICAL STUDY OF COMETS, MINOR PLANETS AND METEORITES (L'ETUDE PHYSIQUE DES COMETES, DES PETITES PLANETES ET DES METEORITES).

Report of Meetings, 26, 27 August and 1 September 1976

PRESIDENT: A. H. Delsemme SECRETARY: J. Rahe

26 August 1976

REVIEWS ON TRANSIENT PHENOMENA IN COMETS

This session was dedicated to Karl Wurm's memory.

1. The Neutral Coma - L. M. Shul'man (in absentia)

The large abundance of H and OH in the neutral comas is generally accepted as evidence of water ice as a major constituent of the nucleus, although recent arguments suggest CO_2 as another major constituent (Biermann and Diercksen, Delsemme and Combi). Two other parent molecules have at last been detected, namely CH_3CN and HCN, whereas the observed radicals C_2 and C_3 suggest complicated unsaturated molecules, whose origin is still controversial (Stief, Shul'man, Kaimakov, Cherednichenko). After the discovery of the Lyman alpha halo, a number of models of the hydrogen atmosphere have been developed. The proper radiation transfer was studied and applied by Keller. The dynamics of the neutral gas in comas has been extensively studied by different workers (Wallis, Shul'man, Mendis and co-workers). Recent work agrees on some general features. A collision-dominated flow takes place in the inner part of the coma (typically 10^4 km). Photochemical reactions give a large contribution to the energy balance of the coma. Heating from gas-dust interaction is much smaller than that from photodissociation in a water-dominated coma (Wallis). A multi-component hydrodynamic model including an extended source of water (icy halo) is described by Ip and Mendis. Many reactions, including charge-exchange reactions can take place in the dense part of the coma and therefore can reshuffle the neutrals (Akin, Oppenheimer).

2. The Cometary Ionosphere - D. A. Mendis

The physical structure and chemical composition of the cometary ionosphere were discussed. The relative importance of radiative and collisional ionization processes were evaluated, and it was shown that ionization by an energetic flux of electrons discharging from the tail through the inner coma, may be 1 to 2 orders of magnitude more efficient than photoionization. The importance of ion-molecule reactions in determining the chemical structure of the ionosphere was stressed and a detailed ionospheric model computation for a H_2O dominated comet containing some CO presented. The dominance of two hitherto unobserved ionic species H_3O^+ and HCO^+ in the inner ionosphere was noted.

3. Dust in Cometary Comas and Tails - Z. Sekanina

Results of studies of the distribution of light in cometary dust tails were summarized. The emission rate of dust, the particle-size distribution function and the ejection velocity of dust particles were established for a few comets with the use of the Finson-Probstein technique. Attention is drawn to the expulsion of the relatively large particles from comets; these are comparable in size with meteoroids that would produce faint meteors. Infrared and polarimetric methods were also discussed.

4. Review of Plasma Tails - J. C. Brandt

Transient phenomena in comet tails were reviewed from the observational viewpoint with emphasis on the interpretation of apparent motions in the tail, the capture of magnetic field from the solar wind, currents flowing in the tails, and production of the ionized species. Our knowledge of most of these areas is fragmentary, but different lines of evidence appear to indicate magnetic fields greater than $\approx 100_\gamma$ and currents $\sim 10^8$ amperes in the tail. Definite results will require space missions to comets.

ADMINISTRATIVE MEETING

1. Election of Officers for 1976-1979

These elections were the first taking place within the new mandate of Commission 15, resulting from the extension of its terms of reference to the Minor Planets and Meteorites. For this reason they had to be very formal. In order to give all members a chance to vote, the following procedure was used:

1. Nominations were called by mail, and the slate of nominees that had been duly seconded, were proposed by mail to all Commission members.
2. The single-transferable vote system and the majority vote rule was used. Sixty-one members have voted, out of a total of seventy. Professor N. Richter has been unanimously elected President at the first ballot with 61 votes, or 100% of the votes expressed. The Vice-Presidential first ballot yielded: B. D. Donn 33 votes; C. R. Chapman 14 votes; B. J. Levin 7 votes; O. V. Dobrovolskii 5 votes; F. Miller 1 vote; G. Wetherill 1 vote. The second ballot gave B. D. Donn 39 votes; C. R. Chapman 19 votes. The following members of the organizing Committee were also elected, each with more than 90% of the votes expressed by mail: Anders, Chapman, Delsemme, Dobrovolskii, Gehrels each 69 votes; Yavnel 68 votes; Roemer 66 votes; Rahe 65 votes; Arpigny 64 votes; since Arpigny had sent his resignation for health reasons, his mandate was vacant and D. Morrison was unanimously elected for this mandate at the Grenoble Meeting. Since the President, the Vice-President and the other members of the organizing Committee had been elected by mail with more than 2/3 of the votes, the rules were waived and all officers were unanimously elected by applause at the Grenoble meeting.

2. By-Laws of the Commission

a. The following motion has been carried: The members of the organizing Committee should not generally serve more than two consecutive terms; this rule does not apply to the Retiring President; other exceptions should be duly approved by a majority vote of the other members of the organizing Committee. The terms of the present officers will be counted from the Sydney 1973 Meeting.

b. After discussion, the motion, seconded by mail, for the Constitution of several permanent working groups to separate comets, minor planets, and meteorites within the Commission, has been lost.

3. Ad-Hoc Committees of the Commission

1. Committee for Cometary Archives (October 1974)
Chairman: A. H. Delsemme; Members: J. Rahe; H. L. Giclas.

2. Committee on Cometary Observations and Experiments in Space (August 1976) Chairman: M. Greenberg; Members: J. E. Blamont, A. H. Delsemme, B. Donn, H. U. Keller.

3. Committee on Minor Planet Observations from Space (September 1976) Chairman: D. L. Matson; Members: C. R. Chapman, A. Dollfus, L. Kresak, D. Morrison, G. Wetherill, K. and I. van Houten.

4. Committee on Cometary Spectra (September 1976) Chairman: B. Donn; Members: C. Arpigny, A. H. Delsemme, G. Herbig, P. Wehinger.

The mandate of the first of these committees has been confirmed and the last three committees have been created by motions unanimously carried on August 26 (1 and 2) and September 1 (3 and 4).

4. Report of the Committee for Cometary Archives

This Committee was constituted in October 1974, upon recommendation of the participants of IAU Colloquium No. 25, and immediate approval by the attending members of the Organizing Committee of Commission 15. A. H. Delsemme was elected chairman, J. Rahe and H. L. Giclas, members. The Committee has established targets and priorities. As a first step, it will try to publish a limited edition of Bobrovnikoff's notebooks, which are a precious source book on cometary data in the 19th and early 20th century. It proposes also to establish a catalogue, in a format easy to transfer on IBM cards, concerning a limited number of bright comets of the 20th century, beginning with 1908 III and 1910 II. The catalogue would record the location of photographs and spectra, with dates, size and scale of plates, dispersion and range of spectra, assessment of spatial and spectral resolving power, type of guiding, name of observer. The idea, at least at an early stage, is to concentrate the information on comets for which cross-references are likely to be useful. The mandate of this Committee has been extended indefinitely.

5. Resolutions

a) A resolution concerning priorities in comet radio observations is carried and transmitted to the Executive Committee for further action. It reads:

The transitory nature and unpredictable appearance of most comets prevent astronomers from scheduling time on large radio telescopes. In order to exploit the potential for unique comet data as indicated by recent radio observations, the XVIth General Assembly of the International Astronomical Union strongly recommends the priority allocation of time on short notice for comet observations on large centimeter and millimeter wavelength telescopes.

b) A resolution concerning the importance of searches for cometary antitails is carried to be brought to the attention of observers. It reads:

Although the association of meteor streams with short-period comets is well established, direct information concerning separation of large dust particles from the nuclei of short-period comets, available in principle through observations of antitails, is lacking. Because of the special geometrical circumstances required and the general faintness of short-period comets, the opportunities for appropriate observations are rare. Commission 15 therefore calls to the special attention of observers with access to fast, wide-field telescopes the importance of searches for antitails.

6. New Members

New members elected: A. Brecher, C. R. Chapman, C. Cristescu, E. Everhart, A. Eviatar, E. I. Gerard, L. Grossman, S. Grudzinska, H. F. Haupt, T. V. Johnson, H. P. Larson, D. L. Matson, D. A. Mendis, B. Milet, E. Moore, J. S. Neff, L. E. Snyder, K. Tomita, H. J. Schober, M. Wallis, J. T. Wasson, P. Wehinger, S. Wyckoff, B. H. Zellner. The Commission now counts 94 members.

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27 August 1976

SESSION OF SHORT PAPERS ON RECENT RESULTS, WITH EMPHASIS ON COMET WEST 1975n.

1. Production Rates in Comet West, derived from Rocket Spectra - P. D. Feldman and W. H. Brune (in absentia).

Ultraviolet spectra of Comet West were obtained by an Aerobee rocket launched 1976 March 5.49. The principal emission features were lines of C, O and C^+ and bands of OH, CO, CO^+ and CO_2^+. Estimates of the production rates, in units of 10^{28} s^{-1}, are OH: 96; C: 31; CO: 42; O: 110. The CI ($^1D-^1P^0$) line at 1931 A indicates that a large fraction (possibly one third) of the carbon is produced at the metastable ^1D state.

2. Low-Resolution Photoelectric Spectrophotometry of the Inner Coma of Comet West - J. S. Neff and Dean A. Ketelsen.

Absolute flux measurements were obtained at 23 wavelength points separated by 123.2 A with a 130 A bandpass between 3100-5800 A on seven nights. The continuous albedo was found to be wavelength independent. Five continuous flux wavelengths were found to vary as $r^{-3.30}$ Δ^{-2} with no suggestion of a phase angle dependence. Thus if scattering is important in producing the continuous spectrum the scattering in this wavelength range is colorless and diffuse. The specific intensities of NH, CN and C_2 bands were found to vary as $r^{-8 \text{ to } 9.4}$ for $r>2$ AU. For $r<1.0$ the value of n in r^{-n} was between 1.5 and 4. The low values of n for $r<1$ are probably due to temporarily enhanced production of molecules due to the exposure of fresh surfaces when the nucleus fragmented near perihelion.

3. Polarization Observations of Comet West - S. Iobe, K. Saito, K. Tomita, and H. Maehara.

Contour maps of Comet West, showing the polarization intensity and angle were obtained from four photographs in the visible taken by setting the polarizer in front of the focus plane. We found that the light is depolarized in a region adjacent to the core and extending sunwards.

4. Motions of the Plasma Tail of Comet Kohoutek - K. Jockers.

Photographs of Comet Kohoutek 1973 XII are being collected from all over the world to make an atlas of the plasma tail of this comet. It will show the comet several times per each 24 hours and will therefore allow the study of the detailed kinematics of the plasma tail. Preliminary data from this atlas were shown and discussed.

5. A UV Spectrum of Comet West - A. M. Smith, R. C. Bohlin, T. P. Stecher.

Exposure of 1/2 to 32 seconds were made on Comet West with an objective grating spectrograph on an Aerobee rocket. The spectral resolution was 3 A and the field of view was 11^o. Atomic lines identified are CI($^3P-^3P^o$), Si II, and CI($^1D-^1P^o$). Molecules identified are CS, OH, NH and CN. Molecular ions are CO^+, CN^+ and CO_2^+. An absolute calibration was made and we intend to publish absolute intensities for the observed features and continuum.

6. CO^+ Intensity Profiles in Comet West - P. A. Wehinger and S. Wyckoff.

Calibrated spectrograms of Comet West (1975n) have been measured with a PDS microdensitometer as a function of distance in the sunward and tailward directions for CO^+ and H_2O^+ features. Unwidened image tube spectrograms (126 A mm^{-1}, scale perpendicular to dispersion 151 arc sec mm^{-1}) were obtained 1976 March 10-11 when

Comet West was at r = 0.47 a.u. and Δ = 0.94 a.u. The linear extent of the slit at the distance of the comet was ~4 x 10^5 km. Profiles of the relative intensity as a function of distance (log I vs. log ρ) were obtained. Further measurements and analysis are in progress.

7. Ionic Brightness Profiles in Comet West - M. Combi and A. H. Delsemme.

Spectra of Comet West were obtained with the slit aligned along the radius vector to the sun on March 7, 8, 11, 15, 17, 22, 23 and April 3, 5, 7 and 9, 1976. The dispersion was 30 A/mm from 3800 to 4700 A. Brightness profiles of a space resolution better than 4" (about 2500 km) are being obtained from CO^+ (3-0, 2-0, 1-0), N_2^+ (0-0) and possibly CH^+ (1-0) for all dates of March. A density map of each spectrum is being made, using the PDS microdensitometer at KPNO. The instrumental and atmospheric profiles are being removed from the cometary spectra, using the spectrum of one of Oke's standard stars taken before each cometary spectrum.

8. Radio Observations of OH in Comet West - L. E. Snyder, J. C. Webber, R. M. Crutcher, and G. W. Swenson, Jr.

The main lines of OH at 1667 MHz and 1665 MHz have been observed in Comet West (1975n) during post-perihelion passage (9 March through 7 April, 1976) using the 120-ft (37-m) radio telescope of the University of Illinois. Channel widths of 3.13 kHz (0.56 km s^{-1}) and 7.10 kHz (1.28 km s^{-1}) were used. The 1667 MHz line was observed in emission with time-varying intensity. The 1665 MHz line was initially in emission and became stronger than the 1667 MHz line but later changed to weak absorption. Multiple velocity components and daily changes in the emission profile were observed but a zero velocity (with respect to the rest frame of the comet) component was always present. Our results generally tend to support the model of ultraviolet pumping by the sun which was proposed earlier to explain the OH observations of Comet Kohoutek (1973f). For the 17-24 March period, we found an OH production rate Q=2.2x10^{29} s^{-1} which is in rather good agreement with the ultraviolet result of Q=9.6x10^{29} s^{-1} found on 5.5 March by Feldman and Brune (1976 Ap.J. Letters, submitted). For a more complete discussion, see Ap.J. Letters (1976) 209, L49.

9. OH Observations of Comets at 18 cm - E. Gerard, F. Biraud, J. Crovisier, I. Kazes and B. Milet.

Results of observations conducted at Nançay for Comets Kohoutek and West combined with those we obtained at Dwingeloo for Comet Kobayashi-Berger-Milon strongly support the model suggested by Biraud et al. (1974), Astron. Astroph. 34, 163. From March 25 to March 30, 1976 Comet West was tracked not only at the position of the nucleus but also 3'5 east and 3'5 west of it. The measured brightness temperatures of the comet at the latter two positions are both equal to 56%±20% of the nucleus brightness temperature. Therefore Comet West is not a point source when observed with the Nançay radio telescope whose beamwidth is 3'5. The extended source seems to be at least an order of magnitude wider than that observed in optical spectra.

10. A Search for Radio Frequency Emission From CH in Comet West 1975n - E. Churchwell, J. Rahe, H. Keller.

A search was conducted for two hyperfine transitions (F=1-1) and (F=0-1) at 9 cm, of the ground state Λ-doublet of CH in Comet West 1975n, using the 100-m telescope of the Max-Planck-Institute fur Radioastronomie in Bonn/FGR. The observations were carried out on 1976 March 18 at r=0.72 AU and Δ=1.01 AU when the comet had already passed perihelion. No lines of CH were detected above the noise level, but from the observed noise an upper limit on the mean column density, N(CH) in the $^2\Pi_{1/2}$, J = ½ state could be derived. With a full line width at half-maximum intensity of Δv = 5 km s^{-1} and a peak-to-peak antenna temperature ΔT_L(p-p ≈ 0.05K, it was found N(CH) $\leq$ 1.1 x 10^{14} molecules cm^{-2}.

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11. Splitting of Comet West (1975n) - Z. Sekanina

The theory explaining the relative motions of comet fragments in terms of the differential nongravitional forces gives a very satisfactory representation of observations of the nuclei of Comet West until the beginning of June 1976. Systematic deviations, on the order of a few arcsec, in late June and July are apparently due to a normal component of the velocity of separation, amounting to a fraction of 1 m/sec.

12. Microwave Continuum Emission from Comet West - R. W. Hobbs, J. C. Brandt, and S. P. Maran.

We have detected 3.71 cm radiation from Comet West using the interferometer at the National Radio Astronomy Observatory. On 5 March 1976 the comet was unresolved (<1.8") at a flux of 0.040 flux density units (10^{-26} watts/m^2/Hz). These observations are consistent with an emitting region diameter less than 1100 km and effective temperature greater than 330°K (±25%). On 4 March we failed to detect any cometary emission at the level of .010 flux density units.

We interpret this emission as originating thermally in the icy grain halo proposed by Delsemme, but with increased number of particles. The variability makes possible the solution of these problems easily consistent with the theory of icy grain halos, particularly since the nucleus of Comet West probably split on 5 March.

13. Chemistry of the Inner Coma, A Progress Report - W. F. Huebner.

The composition of the inner coma is modeled assuming that about 30 chemical species composed of H, C, and O undergo reactions. Ionization and dissociation by solar radiation and over 100 forward and reverse reactions between atoms, molecules and ions are considered in the kinetics. Vaporization from a simple H_2O - CO_2 nucleus provides the initial composition of the gas near the surface.

14. Franck-Condon Factors for the Interpretation of Comet Kohoutek's Spectrum of H_2O^+ - B. Petropoulos and R. Botter.

Franck-Condon factors have been calculated for H_2O^+, by the use of the Rydberg-Klein-Rees-Cooley method; they are in good agreement with experimental results, and they will be used for the interpretation of the spectrum of Comet Kohoutek.

1 September 1976

JOINT MEETING OF COMMISSIONS 15, 20 AND 22. RELATIONSHIPS BETWEEN COMETS, MINOR PLANETS, METEORITES, AND METEOROIDS.

This meeting was intended to cover some of the highlights of IAU Colloquium No. 39, that had taken place two weeks before, in Lyon, France; here the emphasis has been put on the astronomical relationships and the field of meteoritics has rather been neglected.

1. Asteroids: Their Relationships to Meteorites and Comets - C. R. Chapman.

Observations and interpretations of the physical properties of asteroids have been revolutionized in the last few years. We now have data on spectral albedos and diameters for hundreds of asteroids. In general, many meteorite types are found to be represented among the main belt asteroids, although parent bodies for the ordinary chondrites and apparently chondritic Earth-approaching objects are rare or absent in the main belt. Bias-corrected statistics have been assembled on the distribution of the major compositional types as a function of diameter and semi-major axes. Syntheses of these data into plausible scenarios for the geochemical, collisional, and orbital evolution of asteroids are in a preliminary stage. But it is likely that the asteroids, perhaps along with comets, played an especially important role in early chapters of planetary history and that they hold unique clues to fundamental early solar system processes.

2. Comets, Minor Planets and Meteorites: Orbits and Relationships - G. Wetherill.

Ceplecha has identified about 2/3 of analyzed fireballs with meteorite classes (ordinary and carbonaceous), based on ablation and fragmentation. Orbits of fireballs show that most were first earth-crossing with aphelion near ~4 A.U., a property shared by ordinary chondrites, indicated by distribution of radiants and time of fall (Simonenko, Wetherill). Some short-period comets share this property with asteroid fragments accelerated in the 2:1 Kirkwood Gap. Scholl and Froeschle have now shown the 5:2 gap to be possibly more effective. Irons and achondrites are most naturally associated with the innermost asteroid belt, accelerated by non-linear interaction of Mars perturbations and the 7:5 resonance of Williams. Earth-impacting fragments are certainly derived from Apollo and Amor objects, but identification with known meteorite types continues to present problems.

3. Cometary Meteoroids - P. M. Millman

This review covers the mass range of interplanetary particles from a few kilograms down to 10^{-12} grams. Dynamical evidence, supported by physical data, suggests that the great bulk of this material encountered by the earth is of cometary origin and has an integrated mass peak near 10^{-4} to 10^{-6} grams. Several teams of scientists are now active in the collection and study of small particles of extra-terrestrial origin at the low-mass end of the above range near 10^{-8} or 10^{-10} grams. Quantitative studies of the chemical composition of both the large and small meteoroids by four distinct experimental techniques suggest that the relative abundances of some 10 or 12 common elements correspond closely to those of the carbonaceous chondrites type I, in other words, to very primitive undifferentiated material.

4. The Chemical Nature of the Cometary Nucleus - A. H. Delsemme.

Cometary dust reflects the infrared spectrum of silicates, whose vaporization can explain metallic lines seen in spectra of sun-grazing comets. The gas-to-dust ratio R observed in Comets Arend-Roland and Bennett is 3 to 9 hundred times as small as that predicted from solar abundances. However, if we call "primitive" ($=R_0$) the solar ratio after excluding free hydrogen and helium, then $R \simeq R_0$ in Bennett whereas $R \simeq 1/3\ R_0$ in Arend-Roland. The Lyman α halo clearly comes from that hydrogen that was originally bound in molecules like H_2O, HCN and CH_3CN. Of course the observed R's are only production-rate ratios; since they are both close to R_0, we assume that both comets were a rather homogeneous mixture of frozen gases and dust, so that the dust was dragged away almost in proportion to the gas production rate.

Another clue is the C/O ratio. If we assume that the volatile fraction of comets comes from the solar nebula, this C/O "primitive" ratio must be higher than the solar, because of the removal of some oxygen by the condensation of the silicates. Deduced from Ross and Aller's (1976) abundances, it (nominally) is 0.88, although it could be as low as 0.5 and, interestingly, higher than 1. Recent U.V. rocket spectra give C/O = 0.23 for comet Kohoutek and 0.28 for comet West, low enough in both cases to be probably outside the error bars of the "primitive" ratio. Models suggest that 70% of the carbon was not condensed because it was in CH_4 (or 95%, if still in CO); therefore R(new comets) would rather be 1/2 or 1/3

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R_O. Dust accretion into larger grains, more difficult to drag away, leading eventually to the building-up of a "crust", could explain the apparently larger R of a rather old comet like Bennett; these views are confirmed by Encke's infrared continuum. All this is consistent with a primitive condensation temperature larger than 55°K (or 45° K if CO) whereas it must be lower than 120°K in order to condense CO_2. Indeed, recent results (Delsemme and Combi, Ap.J. Letters, 1 November 1976) suggest that CO_2 is another major constituent of cometary snows, bringing to four (with H_2O, HCN and CH_3CN) the number of parent molecules reasonably well identified. Surprisingly, thermal equilibrium models of the solar nebula are not ruled out to explain these four molecules as major constituents of the condensable fraction of this nebula between 50° and 120°K (Delsemme and Rud 1976), although several other hypotheses must still be explored.

5. The Significance of Cometary Nuclei - F. L. Whipple.

Observation unambiguously supports the theory that cometary nuclei are a low-temperature condensate and agglomerate, formed presumably in the outer primitive solar nebula. Comets are the logical building materials for Uranus, Neptune and several major satellites. Some asteroids may be defunct cometary cores. Comets undoubtedly contributed to the volatiles of the terrestrial planets. To Earth they may have added a major fraction of the life-giving elements.

Because of the vital role played by comets in the formation of the solar system, they deserve intensive study by all possible methods, especially by unmanned space missions.

6. NASA's Cometary Science Program - B. D. Donn

NASA's primary effort in cometary research is expected to be a flyby mission in the 1980's. The tentative plan is a proposed new start in 1982 for dual spacecraft launched from the space shuttle in 1985. One spacecraft intercepts Comet Halley and the other, first comet Giacobini-Zinner and then Comet Borrelly. In anticipation of a comet mission in about a decade, a program is being initiated for instrument development with emphasis on neutral and ion mass spectrometers, dust composition analysis and imaging devices. A comprehensive cometary research program consisting of observational, theoretical and laboratory investigations forms a second part of NASA's Cometary Science Program.

FINAL ADMINISTRATIVE MEETING

Several items of unfinished business were taken care of during a final administrative meeting that took place on September 1, 1976. Most of the final decisions have been reported earlier for clarity. The final list of Consultants of Commission 15 was also established. They are: M. F. A'Hearn, V. A. Bronshten, Ed Bowell, L. R. Burlaga, A. I. Ershkovich, W. K. Hartmann, C. F. Lillie, R. Ong, M. Pérez de Tejada, F. Scaltriti, M. Shimizu, V. Zappala.

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COMMISSION 16: PHYSICAL STUDY OF PLANETS AND SATELLITES (ÉTUDE PHYSIQUE DES PLANÈTES ET DES SATELLITES)

Report of Meetings, 27, 31 August and 1 September 1976

PRESIDENT: C. H. Mayer

27 August 1976

JOINT DISCUSSION WITH COMMISSION 17: SPACE MISSIONS TO THE MOON AND PLANETS
Chairmen: F. El Baz, E. Anders

N. Ness: Magnetic Field of Mercury.
S. K. Runcorn: Magnetic Field of the Moon.
J. A. van Allen: Magnetospheres of Jupiter and Saturn.
M. Marov: Results From Venera 9 and 10-Surface and Atmosphere of Venus.
M. J. S. Belton: Cloud Patterns-Waves and Convection in the Venus Atmosphere-Results From Mariner 10.
W. K. Hartmann: Bombardment Histories for Mercury, Mars, and the Moon.
T. Gehrels: Jupiter Atmosphere-Results From Pioneer 10 and 11.
B. A. Smith: Preliminary Results From the Viking I Mars Orbiter.
S. I. Rasool: Preliminary Results From the Viking I Mars Lander.
S. I. Rasool: Future U. S. Planetary Space Missions.

31 August 1976

ADMINISTRATIVE SESSION

The proposal to the scientific unions for an International Solar System Program and the form of its recommendation to the ICSU by COSPAR were reviewed by C. de Jager with additional comments by S. K. Runcorn and A. Dollfus. The consensus of the following discussion, which included Presidents and representatives of other interested Commissions (4, 7, 17, 22) and of the Planetary Data Centers and the IAU Working Group on Numerical Data, was to endorse participation by interested Commissions of the IAU.

Proposed joint resolutions by Commissions 4 and 16: (1) to organize a Joint Working Group to study and report recommendations on the cartographic coordinates and rotational elements of the planets and satellites, and (2) on the Physical Ephemeris of Mars were discussed and approved for presentation to the Commission. A resolution proposed by M. E. Davies to define a new coordinate system for Mercury was discussed and considered appropriate for study and action by the proposed new Joint Working Group.

1 September 1976

I. COMMISSION BUSINESS

The following nominations for officers and organizing committee and a list of 27 proposed new members and one new consultant were presented to the Commission.

President: T. C. Owen
Vice Presidents: B. A. Smith, V. G. Teifel´
Organizing Committee: M. J. S. Belton, D. Gautier, J. E. Guest, C. H. Mayer, S. Miyamoto, D. Morrison, C. Sagan

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Topics discussed included the organization of the Commission, the possibility of maintenance of a current list of physical and orbital elements of planets and satellites, and improvements in the organization of the General Assemblies.

RESOLUTIONS

The following resolutions were approved by the Commission and submitted for approval by the IAU Executive Committee.

1. Joint Resolution of Commissions 4 and 16 on Cartographic Coordinates and Rotational Elements of the Planets and Satellites. (Adopted by Commissions 4 and 16)

Commissions 4 and 16 noting that
(a) confusion exists regarding the present rotational elements of some of the planets
(b) extensive amounts of new data from radar observations and by direct imaging from spacecraft have made cartography of the surfaces of the Moon, Mercury, Venus, and Mars a reality
(c) there will be an extension of these techniques to the mapping of larger satellites of Jupiter and Saturn in the near future

assert that
(a) to avoid a proliferation of inconsistent cartographic and rotational systems, there is a need to define the rotational elements of the planets and satellites on a systematic basis and to relate the new cartographic coordinates rigorously to the rotational elements.

and therefore recommend that
(1) Commission 4 (Ephemerides) and Commission 16 (Physical Study of Planets and Satellites) establish a Joint Working Group to study the cartographic coordinates and rotational elements of the planets and satellites and to report recommendations thereon at the next general assembly of the IAU.

2. Joint Resolution of Commissions 4 and 16 on The Physical Ephemeris of Mars. (Adopted by Commissions 4 and 16)

Considering that recent new determinations of the rotational elements of Mars indicate the need for a revision of the elements currently adopted in the physical ephemeris of Mars, and that a new approach to the definition of the origin of areographic longitudes appears useful (G. de Vaucouleurs, M. E. Davies and F. M. Sturms, Jr., J. Geophys, Res. 78, 4395, 1973), Commissions 4 and 16 recommend

(1) that the tie between the new and current physical ephemeris of Mars be firmly established by appropriate comparisons between ground-based and Mariner coordinate systems, and
(2) that new elements and a new definition of the origin of the areographic longitudes consistent with the results of (1) above and the definitions adopted previously (IAU Trans. XVB, 107, 1973) be incorporated in the physical ephemeris of Mars as soon as deemed practicable in the judgement of the cognizant Directors of the National Ephemerides Offices.

II. SCIENTIFIC SESSION

INVITED REVIEWS

R. Smoluchowski: The Interiors of the Outer Planets.

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G. Pettengill: Radar Studies of Planets and Satellites.
D. Campbell, G. Pettengill: Arecibo Radar Maps of Venus.
R. Goldstein: Goldstone Radar Mars of Venus.
D. Morrison: Recent Research on Planetary Satellites.
A. Betz: Infrared Heterodyne Spectroscopy of Planetary Atmospheres.
G. Hunt: The Lower Atmosphere of Jupiter.
D. Gautier: The Upper Atmospheres of the Outer Planets.

SHORT REPORTS

A. Dollfus: Report on the IAU PLanetary Photographic Data Center at Meudon.
W. A. Baum: Report on the IAU Planetary Research Center at the Lowell Observatory.
B. Andrew: Longitude Dependence of Mars Radio Emission.
P. Wehinger, S. Wyckoff: Io's Extended Sodium Cloud Torus.
W. Irvine: Saturn's Rings.
C. Macris, B. Petropoulos: Seasonal Variations of the Pressure in the Martian Atmosphere.
F. Johnson: Solar System Formation.

COMMISSION 17: THE MOON (LA LUNE)

Report of Meetings, 28 August - 1 September, 1976

PRESIDENT: S.K.Runcorn SECRETARY: J.A.O'Keefe

BUSINESS MEETING

The business meeting of Commission 17 was called to order at 0900 on Thursday 26 August, in Room 14, ENS d'Electrotechnique of the University of Grenoble, Professor S.K.Runcorn in the chair.

A resolution in support of a lunar polar orbiter was read by O'Keefe and passed; see below.

Moutsoulas then brought forward the question of defining the position of a lunar crater. Up to the present, the only practical way to define the position of most lunar craters has been as the center of the rim, since only the rim has been visible. Orbital photography, however, would now permit the use of other points, such as a central peak, or a central point on the crater floor. For the sake of continuity with the older observations, it is important that we should continue to use the center of the rim, even though the points so defined are high above the level of the lunar surface near the crater. A resolution was therefore passed making the center of the rim the reference point for selenographic measurement; for the text see below.

The chairman then drew attention to the International Solar System Decade, proposed by COSPAR and ICSU, to be modeled on the IGY and the IQSY. The purpose is to coordinate studies of the solar system with chemists, physicists, mathematicians and others, as well as with ground-based observatories. Special emphasis seems appropriate on the use of new infra-red detectors. W.A.Baum commented that voluntary programs of this kind are not sufficient; telescopes must be dedicated to the program. A joint meeting on Tuesday, 31 August, was announced.

The chairman then announced the names of E.Anders for the next president of Commission 17, and K.P.Florensky for vice-president; these were accepted without objection.

RESOLUTIONS

The following resolutions were passed without objection:

1. The International Astronomical Union noting that improved values of the second harmonic are critical to theories of the lunar interior and noting further that the free librations of the moon provide an important clue to its past (impact or volcanic) urges that subsatellites be put in polar orbit round the Moon, to determine its gravitational field, especially for the low harmonics, as precisely as possible.
2. We recommend that the long-established practice of referring lunar crater coordinates to the center of the crater at the mean elevation of the rim be continued, noting that such coordinates pertain, in general, to positions elevated above the immediate surroundings.

SCIENTIFIC SESSIONS

A half-day of discussion was devoted to Working Group No. 1, "Figure et rotation de la Lune". The session was held at 1400 on 25 August in Room P1 of the building Sciences Physiques of the University of Grenoble. The general theme of the discussion was the need for more precise theoretical developments to meet the needs of modern observations. The speakers and their titles were as follows:

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1. Mr.L.V.Morrison, Greenwich Observatory, "Comparison of occultation observations with lunar theory".
2. Dr.J.Kovalevsky, Observatoire de Meuden, "Developments in analytical theory".
3. Dr.T.C.van Flandern, U.S.Naval Observatory, "Comparison of occultation observations with integrations".
4. Dr.V.K.Abalakin, Institute of Theoretical Astronomy, Leningrad, "Estimated accuracy for lunar parameters from laser ranging".
5. Dr.J.G.Williams, Jet Propulsion Laboratory, NASA, "Results from laser ranging".
6. Dr.D.H.Eckhardt, USAF Cambridge Research Laboratories, "Developments in analytical theory".
7. Professor A.H.Cook, Cavendish Laboratory, "Theory of lunar librations".
8. Dr.L.A.Shimerman, Defense Mapping Agency, St.Louis, "The expanding Apollo control system".
9. Dr.J.G.Williams, Jet Propulsion Laboratory, NASA, "Results from lunar laser ranging", second part.
10. Dr.C.C.Counselman, III, Massachusetts Institute of Technology, "Results from Very Long Range Baseline Interferometry".

After the business session, on Thursday, 26 August, a scientific session was held on a General Survey of Recent Developments in Lunar Research. The speakers and their titles were as follows:

1. Professor S.K.Runcorn, University of Newcastle, "Physics of the Moon".
2. Professor E.Anders, University of Chicago, "Chemistry of the Moon".
3. Dr.G.Turner, University of Sheffield, "Ages of the Moon".
4. Professor C.P.Sonnett, University of Arizona, "Solar wind induction in the Moon, and its internal electrical conductivity".
5. Dr.T.Johnson, Jet Propulsion Laboratory, NASA, "Lunar Polar Orbiter".
6. Dr.S.Asaad and Dr.J.S.Mikhail (presented by Dr.Asaad), Helwan Observatory, "Report on the lunar work at Kotamia, 1973-1976".

In the afternoon of the same day, Working Group No. 2, "Physics, chemistry and geology of the Moon" met at 1400 in Room D-1, Faculte des Sciences Sociales, for a General Discussion of Processes Involving Surface Features. By correspondence, the Working Group had been discussing the reliability of the impact theory for the origin of most lunar craters. Copies of the correspondence on this subject were made available. The speakers and their titles were as follows:

1. Dr.R.J.Pike, U.S.Geological Survey, "Crater form and cratering process: diagnostic tests from multivariate statistics".
2. Professor T.Gold, Cornell University, "The exogenic view of the lunar surface".
3. Dr.J.A.Bastin, Queen Mary College, "The liquefaction hypothesis: the origin and distribution of marial craters".
4. Dr.J.Green, University of California at Long Beach, "Lunar volcanism at all scales".
5. Dr.J.A.O'Keefe, Goddard Space Flight Center, NASA, "External vs. internal causes of lunar craters: a summary".
6. Dr.J.Iriyama, Chuba Institute of Technology, Japan, "Lunar chronology and evolution inferred from the radiometric age data of Apollo and Luna rocks and soils", and, with Dr.M.Honda, University of Tokyo (presented by Dr.Iriyama) "Movement process of the lunar surface part and the cosmic ray exposure age of the lunar materials."
7. Mr.E.A.Whitaker, University of Arizona, "New approaches to lunar cratering statistics".
8. Dr.C.R.Chapman, Planetary Research Institute, Tucson, Arizona, "Origin of sub-kilometer diameter craters".

On Friday, 27 August, at 0900 in the Weil amphitheater of the University of Grenoble, a joint discussion was held with Commission 16 on Space Missions to the Moon and Planets, for which see the report of Commission 16.

REPORT OF THE WORKING GROUP. "Figure and rotation of the Moon" 1974-1976 by Dr.T.Weimer (chairman)

Le Groupe de travail "Figure et rotation de la Lune" compte en 1976 20 membres; 12 d'entre eux appartiennent a l'U.A.I.; 8 sont membres consultants et ne font pas partie de l'U.A.I.

Entre janvier 1973 et février 1976, 5 bulletins bibliographiques ont été publiés, donnant les références d'environ 160 articles (60 sur la figure, cartographie, etc..., 20 sur la rotation, 80 sur le mouvement orbital, le champ gravifique, etc...). Ce sont là des chiffres équivalents à ceux de la période 1970-73.

Il est inutile de revenir en détail sur les travaux et recherches faits dans les divers instituts; les bulletins bibliographiques tiennent lieu de résumé. Nous nous bornerons à énumérer ci dessous ce qui n'y a pas trouvé place:

-La "Defense Mapping Agency", Saint-Louis (U.S.A.) continue ses travaux de sélénodésie en utilisant surtout les documents obtenus par Apollo 14-17. Voici les sujets des recherches en cours:

1° Relation of Radio Transmitters to Laser Retroreflectors at Apollo 14-15 landing sites;

2° Development of an Apollo Selenodetic System;

3° Development of a new earthbased telescopic Selenodesic System;

4° Lunar positional Reference System (1974) completed.

-K.Koziel à Cracovie (Pologne) a montré que la valeur de f (0,633) déduite des observations héliométriques concorde dans la limite des erreurs, avec celle obtenue par laser (0,642). Il cherche à déterminer la valeur de la libration arbitraire d'apres 10.000 observations héliométriques s'étendant de 1841 a 1945.

-A l'Observatoire de Kiev, Gavilov et ses collaborateurs Kisliuk et Duna

1° etablissent un système de positions sélénographiques de cratères en comparant les différents catalogues;

2° déterminent les hauteurs absolues de 960 points d'après les profils obtenus à l'astrographe de Kiev (D = 40cm, F = 550cm);

3° font d'étude du profil près du méridien 250°W d'après des clichés de "Zond 8" et confirment l'existence de la dépression découverte par l'altimétre laser de Apollo 15-16;

4° comparent les altitudes obtenues à partir de la Terre (catalogue sélénodésique de Kiev) avec celles déduites des observations spatiales;

5° concident, après étude des divers catalogues, que 40 à 100 points suffisent pour définir un système fondamental de références.

-De nombreux travaux sur les problèmes de sélénodésie et le système fondamental de référence ont été faits à l'Institut de Recherche spatiale de l'Académie des Sciences de l'U.R.S.S. (Moscou) par A.A.Gurshtein et ses collaborateurs; ils seront mentionnés en détail dans le bulletin bibliographique no. 14.

Durant la période 1973-76 il n'y a pas eu de découvertes nouvelles sensationnelles. L'heure est à l'exploitation plus complète des observations et au perfectionnement des méthodes d'observation et des théories (détails dans le bulletin bibliographique). Actuellement les méthodes classiques d'observations (visuelles ou photographiques) continuent à coexister avec les techniques les plus modernes telles que photographie depuis les vaisseaux spatiaux, utilisation de cellules photoélectriques ou de laser. Mais il est vraisemblable que dans quelques années les nouvelles méthodes supplanteront les anciennes et fourniront la forme, la libration et même l'orbite de la Lune avec une précision si grande que d'autres domaines en tireront bénéfice. Dès à présent les mesures par laser des distances Terre-Lune ont donné d'excellents résultats pour la rotation de la Terre et les mouvements de son pôle (Observatoire de MacDonald, Texas). On envisage même d'étudier le mouvement des plaques techniques par ces mêmes méthodes (Bender,Silverberg). Cela implique la création de nouveaux centres d'observation laser. Effectivement, en plus des stations existant aux U.S.A. et en U.R.S.S., d'autres sont en cours d'édification en Australie, en France, au Japon, à Hawai.

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Report of Ad Hoc Working Party of Commission 17, IAU, on Transient Lunar Events
by Dr.J.E.Geake

The membership comprised A.Dollfus, Chairman, Paris Observatory, Meudon, France, W.E.Brunk, NASA HQ Washington DC, USA, M.E.Davies, Rand Corpn., Santa Monica, Cal. USA, F.El-Baz, Smithsonian Inst., Washington, DC, USA, J.E.Geake, Secretary, UMIST, Manchester, UK, S.K.Runcorn, University of Newcastle, UK and E.A.Whitaker, University of Arizona, Tucson, Arizona, USA.

Terms of Reference: This ad hoc working party has been set up by S.K.Runcorn, retiring President of Commission 17, to discuss transient lunar events (TLE's), and any action that should be taken to study them.

Definition: TLE's are any temporary changes observed to occur on the Moon. Those reported include obscuration or blurring of surface details, and brightness changes, which are sometimes coloured. They are usually 10-100 km across, and last from a few minutes to an hour or so; some point flashes have also been reported.

The present situation was discussed, and may be summarised as follows:

TLE's reported: The first systematic list of 579 TLE's was compiled by Miss B.M. Middlehurst and others in 1968, from historical and modern records; it was extended by Patrick Moore in 1971 to include a further 134 reports, with an attempt to weight them as regards reliability. An up-to-date catalogue of over 1400 reports is in preparation by Mrs.W.S.Cameron.

Most of the recent reports are from amateur observers, with a wide range of facilities and experience, and it seems probable that many of the effects seen are really caused by atmospheric effects, instrumental aberrations or eye fatigue. However, a few observations have been made by experienced and skeptical astronomers and cannot be so easily dismissed; but these are nearly all visual observations (although usually confirmed by other observers), and there is a serious lack of quantitative instrumental records of TLE's. Probably the most convincing visual observation was by Greenacre & Barr in 1963, using a 24 inch telescope at Flagstaff; they saw sparkling red light in Aristarchus, and this was confirmed by other observers using the 69 inch telescope at Perkins Observatory.

Probably the strongest piece of recorded instrumental evidence is the spectrum obtained by Kozyrev in 1958, which he ascribed to gas emission from the central peak of Alphonsus. Dollfus and Kuiper have both examined the original negative very critically, and separately concluded that it could not be faulted, and that the event was real. Kozyrev later obtained other transient spectra for Alphonsus and Aristarchus.

The only other strong piece of evidence for the reality of TLE's is their correlation in time with lunar perigee, as discovered by Middlehurst - before the same correlation was reported for Apollo seismic events by Ewing et al.. This apparent connection with seismic events, which are themselves not in doubt and which seem very likely at least to disturb surface dust, strengthens the probability that at least some TLE's are real.

Correlation of TLE's in location, with mare rims, was discovered by Middlehurst and Moore, and independently by Mrs.Cameron. This correlation seems plausible in view of the deeply fractured nature of the rock in these regions.

Correlations of TLE's in time and location must nevertheless be treated with caution, in view of the possibility of selective observation, once the supposed correlations were announced. For this reason, Middlehurst has considered it best to ignore all recent observations.

El-Baz pointed out that from the geological point of view there should be some TLE's associated with motions of the lunar surface. Most common among these is the collapse of crater walls that are steeper than the angle of repose. This

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happens most commonly within young or 'Copernician-age' craters. Another type of motion must occur along fractures and graben rilles. It would be logical for this type of vertical motion to occur during times of high moonquake activity (it must be added that the majority of these fractures are concentrated on or near the rims of the lunar maria). Both types of motion would be expected to cause a temporary dust cloud that might be big enough to see from Earth, and could cause the temporary obscuration described by some TLE observers.

Observational attempts to confirm TLE's

The obvious need is for more instrumental evidence of TLE's, and several attempts have been made to use a network of amateur observers, who are willing to monitor the Moon continuously and to alert well-equipped professional observatories when events are reported. Organised attempts to confirm TLE observations were reported by those present, as follows:

(1) Brunk described a program supported by NASA and carried out at the Corralitos Observatory of Northwestern University, in New Mexico, USA. It used a 24-inch reflector, with an image orthicon, a choice of filters, and a zoom lens for image scale selection. The TV output was used, rather than direct observation, and the display could be photographed at any time. The observers were linked by amateur radio to Argus Astro-Net amateur observers at at least 10 locations; both the amateurs' reports and the Corralitos findings were tape-recorded. Reports were also received from amateurs of the Moon-Blink network, who used alternating colour filters to look for lunar colour changes.
The observer in charge at Corralitos was Justus Dunlap. Dr.J.A.Hynek was in charge of the program, under Brunk as NASA monitor until 1971, and R. Bryson thereafter. This program was run for 7 years (1965-1972); 98 amateur reports of TLE's were received and it was possible to check 39 of them. Not one of them was confirmed.
It was pointed out that the Corralitos observers were mostly local students, who were neither professionals nor astronomers. Brunck agreed to circulate copies of the final report of this program (NASA CR-147888) to those present. Both the Astro-Net and the Moon-Blink networks are now inoperative.

(2) Miss Middlehurst organised the Lunar International Observers' Network (LION) from MSC (now JSC) Houston, with NASA support. This operated throughout the period covered by the Apollo 8 - 14 missions. No results are known.

(3) Mrs.Cameron (at GSFC) collects amateur and other observations of TLE's, and has organised a TLE observing program for the Association of Lunar and Planetary Observers (ALPO). This is still active.

(4) H.Ford in Dundee, Scotland, Director of the BAA Lunar Section, is organising a network in the UK, to alert Dr.R.Maddison of Keele University who will check reported TLE's with his 18" reflector, which is equipped with a spectrograph.

(5) Davies reported a JPL program of visual observations using a 16" reflector on Table Mountain. No reporting network was used. No TLE's were observed.

(6) Dollfus reported that he was alerted when a dark-side TLE was reported in 1969, during the Apollo 11 mission. He was at the Pic du Midi Observatory, and the seeing conditions were excellent. He used the 1 m telescope in coronograph mode, to suppress the light scattered by the illuminated crescent, giving unprecedented observational conditions. He immediately observed the site of the reported TLE (the wall of Aristarchus), and at first saw nothing unusual; then he saw some flashes. He was doubtful as to whether they were real, and took a rest, after which he again saw no flashes at first, but did see some after a minute or so. He concluded that the flashes he saw were all due to eye fatigue. He saw no events that he regarded as real during 1½ hours of observation.

(7) Brunk reported a NASA-supported program using a telescope at Port Tobacco, Maryland; the seeing conditions there were poor, and the observers were not astronomers. This observatory took part in the Moon-Blink program, which

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operated for 1½ years from 1964, with Mrs. Cameron as Technical Monitor. 5 events were reported from Port Tobacco: 3 were reported from a similar instrument at Huntsville Alabama, and 2 from one in Edinburg Texas; both of these instruments were run by professional astronomers.
The Moon-Blink alert network (of 12 east coast amateur and professional observatories) was only in operation for the last of the events reported from Port Tobacco (on Nov 15 1965); only 6 of these observatories had clear sky, and of these 4 saw nothing unusual but 2 confirmed an anomaly at the reported lunar site. The Moon was not up at Corralitos.

Relevant NASA observations involving spacecraft, existing or planned.

(1) Davies reported on the Lunar Polar Orbiter: the only relevant instruments will be the Spectro-Stereo Scanner, and possibly the Electron Reflection Experiment. The most directly applicable will be the Spectro-Stereo Scanner: this will scan a 40 km width, swept along by spacecraft motion, with barely overlapping 1^o apart tracks on successive polar orbits. The resolution will be ~ 1 km, and there will be 6 filter bands. It might detect patches of obscuration, but it takes about 360 orbits of nearly 2 hours each to cover the whole Moon, so the chance of happening to catch a TLE lasting a few minutes, and of a few 10's of km diameter, is very small. It would not detect flashes of emitted light, as the data processor would regard these as interference, and ignore them. Also, the scanner is only to be switched on for a small proportion of the time, because the data-recording capacity (required when the LPO is behind the Moon) is required for other experiments. This limitation does not apply to the near-side part of each orbit, when communication is direct. However, the whole thing will probably only be switched on for part of the time, to economise in earth-based communication, space-tracking and data-handling facilities. In short, the chance of the LPO detecting a TLE is probably negligible. It would not be realistic to suggest to NASA any change in the LPO program of observations, in order to look for TLE's. The present mood in the US, as regards funding, is such that the future of the whole LPO program is in some doubt.

(2) The other most relevant NASA experiments are the various Apollo surface (ALSEP) and orbiting (CSM) instruments. Of the surface instruments, the mass spectrometer gas analyser (Apollo 16 only) and the Cold Cathode Gauge (CCG) showed transient gas (e.g. H_2O and NH_4), but this was thought to be of spacecraft origin. These instruments are not now working. 3 of the Passive Seismic Experiments (PSE) are still in operation (at the Apollo 15, 16 and 17 sites) and are still able to locate moonquakes as regards site and depth; correlation of these in time and location with independent evidence of TLE's would be of the greatest interest. However, these instruments are now only interrogated occasionally (when their accumulation of recorded data is acquired) so the discovery of correlation in time with observed TLE's will be difficult. Runcorn suggested that it might be possible to monitor the most likely times of activity (i.e. perigee) more continuously, together with Earth-based visual observation of the 12 or 13 most likely sites.

(3) Instruments used on board the CSM's while in orbit included α-particle detectors. The results were described by Hodges (Commission 17, Aug. 26 1976) and by him and Gorenstein (7th Lunar Science Conf., Houston, March 76). The instrument detected:

(a) He^{++} from solar wind and solar-ionised surface emission

(b) ^{222}Rn (by $^{222}Rn \xrightarrow{\alpha} {}^{218}Po \xrightarrow{\alpha,\beta^-,\beta^-} {}^{214}Po \xrightarrow{\alpha,\beta^-,\beta^-} {}^{206}Pb$)

Estimates of the amounts of those gases released per year from the surface, and from the lunar atmosphere, were given. This evidence is relevant to the possible mechanisms of TLE's, but did not (and could not) give information about separate events.

(4) There were 3 reports by Apollo astronauts, in lunar orbit, of flashes on the surface. Mattingly (Apollo 16) saw one on the Earth-lit dark side of the Moon; it appeared to come from below his horizon, so he could not identify the site. It might have been a cosmic-ray induced eye flash, but he differs from other astronauts in not usually seeing these. On Apollo 17 Schmitt saw a flash in Grimaldi, and Evans saw one on the eastern rim of the Orientale basin. These astronauts were all, by nature and training, skeptical of such events, but they at least agreed that these observations were unexplained; they are discussed in the Apollo 16 and 17 Preliminary Science Reports (under 'Visual Observations', by El-Baz as co-author with the Astronauts).
The Apollo 11 astronauts, while in lunar orbit, were alerted to look at Aristarchus on their next pass, because observers on Earth were reporting activity there; they did so and reported that the NW wall of the crater appeared to be unusually bright. At the same time, two astronomers in Bochum, Germany, observed the same effect.

Possible future NASA-supported observations

Brunk and Davies agreed that there was at present no chance of obtaining NASA support either for a further Earth-based TLE observing program, or for the special use for this purpose of existing or planned spacecraft equipment. Even a recommendation in this direction from a group of internationally recognised astronomers of the IAU would probably be ineffective.
The only approach likely to succeed might be for some distinguished astronomer dedicated to this work, and able to convince others of its importance, to apply to NASA for a general research grant for lunar studies.
Dollfus pointed out that, as Kozgrev's spectra were probably the most convincing evidence to date, it was important that any observer willing to make systematic and extensive spectroscopic observations should be encouraged and supported. Mrs.Cameron at GSFC has indeed been doing this kind of work; she has now photographed over 300 spectra for 20 suspected TLE sites, and has found a possible anomaly on one of them, in the form of an extra absorption line at 4908A in Plato.
A search of Lunar Orbiter photographs, and of Apollo CSM photographs from orbit, might yield evidence of events, especially obscurations. So far, no studies of this nature have been initiated, and this might be well worth doing. Anyone willing to undertake it should be supported, perhaps through the Lunar Science Institute.
The present NASA thinking tends to be dominated by geologists who have little interest in the physical processes implied by TLE's, or even by moonquakes, which they only study in order to elucidate the structure and composition of the lunar interior.

Action to be taken

It was agreed that some of the TLE's reported were probably real, but that no further progress could be made without convincing quantitative instrumental evidence. Unambiguous results, using photography, photometry, and especially spectrophotometry, would be of great interest, and of major importance in increasing our understanding of the physics of the lunar surface.

It was decided that the only immediate action possible was to ask for IAU support for a resolution drawing attention to the importance of this area of investigation. It was therefore agreed to place a proposal as follows before the General Assembly on September 2 1976, from Commission 17:

"IAU Commission No. 17 considers that lunar transient phenomena, that have been reported by many experienced astronomers, warrant further quantitative observational and theoretical studies, especially in view of their suggested correlation with moonquakes and the discovery of releases of argon and radon from the lunar interior." (This was passed by the Assembly)

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COMMISSION 19: ROTATION OF THE EARTH
(ROTATION DE LA TERRE)

Report of Meetings, 26, 27 and 31 August 1976

PRESIDENT: C. Sugawa SECRETARY: H. Abraham

26 August 1976

FIRST SESSION, WITH COMMISSIONS 4, 8, 31 AND 40

Advances in Techniques for the Determination of the Rotation of the Earth

The President opened the meeting and invited R. Anderle to report on polar motion determined by Doppler satellite observations. The speaker said that the standard error in pole positions from 48 hours of Doppler observations was only 7 cm. However, because of uncertainties in the gravity field the standard deviation was 60 cm. This gave a standard error, for a 5-day mean based on two satellites, of 25 cm.

P.L. Bender spoke about determination of the Earth's rotation by lunar laser ranging. The accuracy for a measurement of UT0 in 3 hours was 0.5 ms, or even 0.2 ms, but gaps of several days could occur, especially near new moon. Comparisons indicated that BIH smoothing did not remove real variations and that most causes of LLR scatter were known. His personal opinion was that LLR would give the long term values and LAGEOS would interpolate.

E.M. Gaposchkin spoke on laser ranging to LAGEOS. Artificial satellites had no fundamental longitude reference and so could not determine UT but could be excellent for precise metrology of the Earth. Preliminary LAGEOS results gave a standard error of 4 1/2 cm for a single pass and showed great future potential.

J.D. Mulholland then spoke on the EROLD programme which had been arranged to ascertain whether, initially, five lunar laser ranging stations in four countries could carry out sustained operations successfully. There were good prospects of operating by 1977.

Another technique was presented by C. Counselman who explained determination of the Earth's rotation by VLBI. This was shown to be a powerful means of determining the Love numbers for earth tides, polar motion, universal time, clock comparisons, precession and nutation and the coordinates of celestial sources.

In contrast with the usual VLBI systems, B. Elsmore then discussed the potentialities of measuring UT1 with connected element radio interferometers. Time could be obtained with a radio interferometer built for that purpose, or could be obtained in the course of synthesis mapping. The probable error in UT1 from a simple 12-hour observation with the 5-km telescope, was ± 4.0 ms.

K.J. Johnston described the determination of UT1 using a 35-km baseline. Three antennas, 2.7 km apart, were connected by cable, and a 45-ft dish was situated 35 km from these. This array, which had a baseline of 220,000 wavelengths, formed an interferometer that measures phase difference (whereas VLBI measures delays) and its accuracy was expected to reach about 0".01.

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SECOND SESSION, WITH COMMISSION 31

IPMS Problems (I)

This being a joint meeting the President asked the President of Commission 31, H. Enslin to take the chair and H. Fliegel to be the Secretary. The following is a condensation of the Secretary's detailed report.

B. Guinot explained the MEDOC experiment. The work would be similar to that by DMA but with non-identical networks and a different model of forces. The experiment would attempt to reveal effects due to different reduction programmes and would promote an international scientific polar motion service based on satellite techniques. DMA would collaborate.

A.R. Robbins then gave his report, "A Future International Earth Rotation Service". The speaker summarised correspondence with members of IAG Special Study Group 1.04 and other interested colleagues; this referred to the roles of the ILS, IPMS and BIH and to lunar and satellite laser ranging and VLBI. Correspondents had agreed almost unanimously that it was not yet possible to determine the form of a new service and that the IPMS and ILS were essential at present. He also listed details about the three new systems that will need to be estimated for future debate.

Evidence which supported the IPMS was presented by Wm. Markowitz in a paper, Comparison of ILS, IPMS, BIH and Doppler polar motions with theoretical. For the past eight years the IPMS results had given the best agreement with the model and their annual and Chandler components had been remarkably stable. However, the ILS curve showed large deviations and has a non-periodic component. Markowitz suggested that ILS observations should be continued for some time to permit comparisons of secular motions.

In the ensuing discussion BIH, IPMS, ILS and Doppler results were compared as to agreement, stability, significance and resolution of the 12 and 14-monthly spectral peaks. Members considered basic objectives and the urgency for involvement in new techniques. A particular problem was whether new equipment should be sited for close relationship to existing stations or for best results in the future.

27 August 1976

THIRD SESSION

Observations and Reference System

The need for care in selecting sites for astrometric observations was emphasised by G. Teleki since there could be refraction anomalies of 0".01 even at small zenith distances. The nightly variations of latitude observed at Kitab and Ukiah had opposite signs, and both sites were near to regions where the atmospheric density and radio-refractivity fields were perturbed.

R. Verbeiren discussed the reduction of results obtained by the ILS stations during the past 75 years. Faulty declination corrections affected the results when complete groups were not observed; also changes had occurred in the nutation elements, in the constant of aberration and in the micrometer screw calibrations. Rounding off errors reached at least 0".03. A correction of -".0080 ± 0".004 for the nutation in obliquity had been obtained from the ten pairs of stars that had been observed by the ILS continuously.

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R. d'E. Atkinson spoke about the Earth's axes of rotation and figure. He showed that observations of zenith distance can give completely the pole of figure on the celestial sphere; hence the displacement of the pole of date from the adopted pole of figure is known on the Earth. The Eulerian pole, however, moved on the surface of a fixed cone and, unlike the pole of date, could not be obtained from a single observation.

D. Djurović then discussed the stability of the reference system for observing the rotation of the Earth. In the case of many stations their series of observations did not conform to a certain single formula, nor did many of the classical instruments reproduce the same errors from year to year. There was also correlation between the time and latitude residuals, especially for some of the stations.

FOURTH SESSION

Physical Interpretation

L. Randić spoke on the influence of the rotation axis on declinations. Results indicated that the Earth was not rotating as a rigid body with a unique axis. To find the true nature of the rotation we should compare the declinations of equatorial stars determined from the northern and southern hemispheres.

E.P. Fedorov and Ya. S. Yatskiv emphasised that the CIO was attached to the zenith of the five international latitude stations; it was not fixed to them. Results presented showed how variations occur in the observed axes between these stations; thus there was no sense in considering the CIO as a fixed origin of the polar coordinates.

Ya. S. Yatskiv then reviewed evidence on models of the Chandler wobble. Up-to-date estimates of the parameters agreed well but fluctuations were suggested by the instantaneous values. Suggested causes of the wobble were discussed, including atmospheric and seismic excitations. Finally, problems of the nearly diurnal wobble were reviewed. Observations had shown both prograde and retrograde components.

K. Yokoyama presented a paper by Y. Wako and himself on nutation terms derived from time and latitude observations. The equation for determining the polar position and UT1 from time observations was modified to include a new term. This τ-term described the effect that nutation errors have on the longitude and is analogous to the z-term for latitude observations. It would help in evaluating the nutation amplitudes.

P. Brosche discussed tidal friction of the oceans at present and in the past. Average values of the torque and the energy dissipation exerted by the M_2 tide were presented on the basis of 4° models of the present and Permian oceans. The oceanic tidal friction was probably low at the critical stage when the moon was close to the Earth.

At the request of the President, G. Winkler described the tiltmeter around the USNO PZT. This was a system of plastic tubes containing mercury and mounted on invar. It indicated earth tides but could be affected by temeprature changes or very heavy rain.

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FIFTH SESSION

Administrative Meeting

The report of the IPMS was presented by the Director, S. Yumi. He reviewed the status of reports not only from the ILS and IPMS latitude observations but also from the IPMS time observations. The latter had been calculated both with and without the τ-term. Weights had been estimated both from the internal and the external consistency. Weight from latitude was about twice that from time. Cooperative observations for time and latitude would soon be made with PZTs on the 39°8' parallel at Mizusawa, Kitab, Cagliari, Washington and Ukiah. Doppler satellite observations had been made at Mizusawa and it was reported that Carloforte (or Cagliari), Gaithersburg and Ukiah would be equipped as soon as possible.

The report of the BIH was presented by the Director, B. Guinot. He discussed developments and also the demands for promptness, stability, accuracy and revisions. The BIH origin for coordinates of the pole had been adjusted to the CIO in 1968 but discrepancies between the BIH and ILS results had rapidly appeared. On the introduction of satellite data in 1972 uncertainties in coordinates had been reduced by more than 50% and UT1 had been improved also. The BIH would take part in the EROLD campaign (lunar distances) and in the MEDOC experiment (Doppler observations of artificial satellites). The Rapid Service had been improved since 1976 by the inclusion of USSR data and would continue to be needed for predictions of DUT1. Before 1984 IAU recommendations would be needed as to corrections for the deflection of the vertical, the effect of zonal tides on UT1, the forced diurnal nutation and nutation for a rigid Earth.

Votes of thanks to Yumi and Guinot were passed with acclamation.

S. Yumi next presented the report of the Working Group on the Pole Coordinates. Original data had been collected at Mizusawa, except for missing Batavia data for 1935. The conversion to machine readable form had been done mainly at Mizusawa and should be completed in a year. Carloforte data for 41 years had been punched in Cagliari. Further discussion by the Working Group was needed on the method of reduction, a definition of each station's mean latitude, and on certain errors. Completion was expected by mid-1977, funds permitting. Financial support was gratefully acknowledged. The President thanked Yumi for the report.

H. M. Smith, Chairman of the BIH Directing Board, spoke about revising the statutes of the BIH. After discussions on the BIH pole, the IPMS pole and the pole of figure a committee was chosen to draft a resolution.

The meeting stood in memory of Dr J. Witkowski, former member of Commission 19, who died on 25 May 1976.

It was agreed that the names of the following members should be submitted to the Executive Committee for future office.

President: R. O. Vicente
Vice-President: P. E. G. Pâquet
Organizing Committee: H.J. Abraham, P.L. Bender, B. Elsmore, H. Enslin, K. Lambeck, G. Teleki, C. Sugawa, Ya. S. Yatskiv, G. Winkler, S. Yumi (ex officio).

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31 August 1976

SIXTH SESSION, WITH COMMISSION 31

IPMS Problems (II)

E. Proverbio spoke on the status of Cagliari/Carloforte. At Carloforte living conditions and logistic and legislative problems hindered recruitment and scientific development; consequently an observatory was to be set up near Cagliari. Bureaucratic delays had retarded construction until 1975 but observations had been made at Cagliari University with the 80 mm VZT. Despite the latitude offset and provisional screw value the mean external error of a pair per night was ± 0".48. (The 100 mm VZT at Carloforte gave ± 0".28). Instruments for the new site would include the 80 mm VZT, a Danjon astrolabe, the old Mizusawa PZT, a Doppler station and a laser station. It would seem useful to transfer the Carloforte VZT there too, to compare the old and new techniques.

S. Yumi reported on the 39°8' ILS stations meeting that was held in Cagliari on 20 and 21 August 1976. It had been small but successful. The meeting considered that the ILS observations, extending from 1899, had the advantage of being free from star position errors, could reveal local effects and warranted further investigation. It was tentatively agreed that ILS observers should be exchanged in a 4-year programme to ascertain relative personal equations. With reference to the prospective chain of PZT stations on 39°8' it was also tentatively agreed that there should be a unified star list, observing programme and reduction method, and weekly airmail transmissions of data on punched tape. Lisbon Observatory proposed to set up a time and latitude station on 39°8' very shortly.

G.A. Wilkins reported briefly on IAU Colloquium N°35 on "The Compilation, Critical Evaluation and Distribution of Stellar Data" which had just been held at Strasbourg. (See report of meetings of Commission 5 for further details of the Colloquium and of the recommendations that have been based on its discussions).

H. Fliegel spoke on timing and polar motion as applied to space research. He explained that Doppler shift measurements showed the rate of change of range, and this fluctuated because of the Earth's rotation. The phase depended upon UT1 and the longitude of the station. Conversely, the observations could determine this. A frequency error of 10^{-12} would correspond to 5 metres in longitude. The BIH Rapid Service give sufficient accuracy for present programmes.

The following resolutions, each in English and French, were adopted by the joint meeting.

The International Astronomical Union

recognizing
that the activities of the International Polar Motion Service and of the Bureau International de l'Heure are complementary, and that they both make essential contributions towards the determination and understanding of the motion of the pole, and

recognizing
that the new laser and radio techniques will make an important contribution to the study of polar motion but that it is at present too early to determine the form of a new service based on these techniques, and

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noting
with satisfaction that the International Polar Motion Service multi-station derivation of polar motion has attained the precision needed to resolve long-standing problems,

recommends
that the International Polar Motion Service continue to operate in its present form, and that the Scientific Council of the International Polar Motion Service and the Directing Board of the Bureau International de l'Heure jointly keep under continuous review the possibility of the utilisation of modern techniques on a permanent basis, and

urges
that the international and national agencies concerned continue their support of the Central Bureau of the International Polar Motion Service and of each cooperating observatory.

The International Astronomical Union, in accordance with previous resolutions of the International Astronomical Union and of the International Union of Geodesy and Geophysics,

recommends
that the five ILS observatories (or their replacements) be equipped with photographic zenith tubes and Doppler satellite tracking equipment, and that their existing visual zenith telescopes be not phased out until there has been a sufficient overlap of simultaneous observations.

At the conclusion of the meeting the President expressed his appreciation of the work done by members of the Commission and a vote of thanks to the President was carried with acclamation.

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COMMISSION 20: POSITIONS AND MOTIONS OF MINOR PLANETS, COMETS, AND SATELLITES (POSITIONS ET MOUVEMENTS DES PETITES PLANETES, DES COMETES ET DES SATELLITES)

Report of Meetings, 25 and 30 August, and 1 September 1976

PRESIDENT: L. Kresák. SECRETARY: E. Roemer.

25 August 1976

FIRST ADMINISTRATIVE SESSION

The President welcomed members of the Commission and announced the appointment of H. Scholl and C. Froeschlé as interpreters and of E. Roemer as secretary. All present stood in silent respect as the names of members and former members deceased during the triennium were read: G. A. Chebotarev, G. M. Clemence, S. Herrick, H. G. Hertz, H. M. Jeffers, G. P. Kuiper, E. Rabe, and G. Van Biesbroeck.

It was announced that, for lack of a second proof, the few corrections that had been suggested by members to the Report of the Commission could not be made. The most notable among these concerned the observational program on minor planets and comets with the 33-cm astrograph at Perth.

Unanimous approval was given to the proposed list of new members of the Commission: V. K. Abalakin, A. Borsenberger-Bec, J. A. Burns, O. Calame, M. A. Dirikis, D. W. Dunham, R. Dvorak, F. A. Franklin, C. Froeschlé, B. Garfinkel, A. C. Gilmore, T. Kiang, Y. Kozai, J. D. Mulholland, P. E. Nacozy, D. Pascu, E. M. Pittich, H. Scholl, P. J. Shelus, G. E. Taylor, R. M. West, and D. K. Yeomans. Accepted as consultants were: N. A. Belyaev, N. S. Chernykh, E. Helin, H. Rickman, V. A. Shor, S. Vaghi, V. Zappalà, and K. Ziolkowski.

The proposed new officers of the Commission, B. G. Marsden, President, and G. Sitarski, Vice-President, and members of the Organizing Committee, F. K. Edmondson, P. Herget, E. I. Kazimirchak-Polonskaya, L. Kresák, W. H. Robertson, J. Schubart, together with the chairmen (ex officio) of all Working Groups, were then accepted unanimously. [S. Ferraz-Mello, E. Roemer, and G. E. Taylor were confirmed as Working Group chairmen at the second administrative session of the Commission.]

A proposal to the IAU Finance Committee for renewal of the subvention toward the support of the Minor Planet Center at the Cincinnati Observatory also received unanimous support. [The amount of S Fr. 6220 for the triennium 1977-1979 subsequently was approved on the recommendation of the Finance Committee.]

Marsden then reviewed proposals for changes in the form and contents of the annual ephemeris volume for minor planets that is prepared at the Institute for Theoretical Astronomy, Leningrad. Suggestions from a number of sources had been discussed by the Organizing Committee in consultation with Abalakin. These included (1) A tabulation of osculating elements and absolute magnitudes $\underline{B}(1,0)$ for each object annually, (2) An augmented list of bright minor planets and special objects for which extended ephemerides to the improved accuracy of $0^m.01$ and $0^s.1$ should be given, and (3) Revision of the precepts for calculation of ephemeris magnitudes, in that both phase and opposition effects should be included in the extended ephemerides, but they should continue to be excluded in calculation of ordinary opposition ephemerides. Comments were invited so that a comprehensive recommendation could be presented for consideration at the appropriate time.

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Roemer read a resolution proposed by herself and E. I. Kazimirchak-Polonskaya urging follow-up astrometric observations of recently discovered and particularly interesting minor planets, comets, and satellites over the longest possible arc and calling special attention to the need for observations with large telescopes.

Formal consideration of these and other recommendations and resolutions, none of which was expected to require joint action with another Commission or was to be referred explicitly to the General Assembly, was deferred to the second administrative session.

FIRST SCIENTIFIC SESSION ON MINOR PLANETS

Scientific reports were then presented as follows:

(1) T. Gehrels and C. J. van Houten: Palomar-Leiden Survey of the Various Populations of Minor Planets. Gehrels described the observational programs with the Palomar Schmidt telescope to search for special populations of minor planets, to study light variation of faint asteroids, and to improve population statistics generally. Van Houten reported on analyses of the photographic plates at Leiden, particularly regarding measurements of positions for use in computation of orbits, and photometric calibration of the plates of the two Trojan search programs. It is unclear whether the very considerable work involved in determination of positions and orbits for the 1300 normal asteroids observed in the 1971 and 1973 Palomar-Leiden Trojan surveys would be justified by the improved knowledge of asteroid statistics that might result.

(2) V. I. Orel'skaya: Present Status of the Observations of Selected Minor Planets for Improving the Constants of Star Catalogues. (Read by P. Herget.) Nearly 23,000 precise observations of 10 bright minor planets for use in improving constants of star catalogues have been collected by the Institute for Theoretical Astronomy from 21 cooperating observatories in the years 1949-1975. A proposal is made for a new project involving observations of 20 selected objects, including 10 new ones chosen to obtain even coverage over the declination band to ±30°, during the years 1974-1990. Some 35 observatories have agreed to cooperate in the new program.

(3) T. Gehrels: Photographic Photometry of Faint Asteroids and the Ephemeris Magnitudes. A new list of absolute magnitudes, $\underline{B}(1,\overline{0})$, verified by photoelectric observations to magnitude 14-15, is in preparation. New observations are planned to obtain standardized photometric data for recently numbered minor planets. The brightness surge at phase angles less than about 7° (opposition effect) has now been well studied in six objects. There is some evidence that the phase effect differs between bright and faint asteroids, and that it may be correlated with compositional type. Retention of the coefficient 0.023 mag/degree for ephemeris purposes is recommended. Use of the symbol $\underline{g}$ for absolute magnitude should be dropped.

<u>30 August 1976</u>

SCIENTIFIC SESSION ON COMETS

The session was organized and presided over by E. Roemer, chairman of the Working Group on Orbits and Ephemerides of Comets. Short reports on observational topics were presented by the following speakers:

(1) Y. Kozai (with Ko. Tomita): Comet Patrol Observations in Japan. Factors that have contributed to the great success with comet discoveries of amateur astronomers in Japan include a favorable longitude, without large population centers for a long distance to the east, widespread availability of suitable small telescopes, great public interest encouraged through popular journals and by many groups for amateur astronomers, and also by the Astronomical Society of Japan, which has awarded since 1907 a medal to any Japanese astronomer who discovers a new celestial object. Time on a number of the main instruments of the Tokyo

Astronomical Observatory is available for observation of comets, but light pollution from industrial areas near the Okayama and Dodaira Stations has seriously hindered recent work. The Tokyo Astronomical Observatory acts as a Central Bureau in Japan, coordinating confirmation of possible new discoveries.

(2) T. Gehrels: Discoveries of Faint Comets with the Palomar Schmidt Telescope. Five comets have been found on plates taken with the Palomar Schmidt in the continuing work on minor planets. Two, of magnitude 15-16, were found immediately upon inspection of the plates. Three others, of magnitude 18-19, were found by careful blink examination. One comet has unusually large perihelion distance, and four, including the accidentally rediscovered P/Swift 1, renamed P/Swift-Gehrels, are of short period.

(3) E. Roemer: Observations of Faint Comets with Large Reflectors. Because of the large scale and limited field of typical large reflecting telescopes (10"/mm and 35', respectively, for the two large telescopes of the University of Arizona), the position of an object to be observed must be fairly well known, and the calculated motion must be compensated during the exposure. The "nuclear" (m_2) magnitudes are appropriate for determination of the required exposure. Use of the Astrographic Catalogue, or of field transfers, is necessary in astrometric reductions because of the small field. Semiaccurate positions, accurate to $0\overset{s}{.}1$, can be scaled by careful use of a reseau.

(4) R. M. West (with H.-E. Schuster): Discovery and Observation of Comets with the ESO 1-m Schmidt Telescope. Plates taken in the survey of the sky from -90° to -20° provide a unique opportunity for discovery of minor planets and comets. The plates are first checked visually at La Silla, then at the Sky Atlas Laboratory in Geneva, whither they are transported weekly by air. Negative glass copies are sent as soon as possible to the Uppsala Observatory, where the plates are again searched for special objects. The triple search is believed to be thorough enough that no exceptional asteroid trails or comets brighter than 18th magnitude have escaped detection. Six comets have been found on the 729 plates obtained in the interval 1973 to mid-1976, three of them being new; two more were already known, and no confirmation could be obtained for the other. Discovery rates for new comets are approximately 1 comet/year, or 1 comet/6000 sq. degrees, and twice these rates for all detected comets.

(5) J. Hers: Comet Observations in South Africa. With concentration of the South African observational facilities at Sutherland, J. A. Bruwer, who continues to use the 10-inch Franklin-Adams camera, is now the only observer of comets in South Africa on a professional basis. Hers uses his own 20-cm Celestron reflector to obtain 15-20 precise positions a year. J. C. Bennett, Pretoria, continues to use a 20-cm telescope in search for new comets.

(6) E. Høg: Reference Stars in the Southern Hemisphere. The Perth 70 catalog of positions of 24,900 stars, compiled by the expedition of the Hamburg Observatory to Perth as a part of the SRS International Program, is now available in both machine-readable and printed form.

Reporting on theoretical investigations were the following:

(1) M. Bielicki: Present Status of the Catalogue of Orbits of One-Apparition Comets. (Read by E. Roemer.) Almost all of about 50,000 original observations of 165 comets observed in the interval 1900-1950 have been collected in Warsaw. Some 15,000 observations of comets observed between 1800 and 1900 have been collected in Czechoslovakia, through the cooperation of the Astronomical Institute of the Slovak Academy of Sciences. Reduction and analysis of observations is in progress. Most of the necessary computer programs for calculation of gravitational perturbations and determination of Newtonian osculating elements near perihelion are completed.

(2) B. G. Marsden: Recent Results on Short-Period Comets. The discovery of six new short-periodic comets in the year 1975, resulting mostly from patrols with Schmidt telescopes, is quite remarkable--and presented a number of problems with bungled discovery reports and marginally adequate follow-up. If not all short-period comets are to be observed at each return, how is a selection to be made when one cannot fully anticipate the flares of P/Tuttle-Giacobini-Kresák, the selection of targets for space probes, or the need for highly accurate ephemerides of close-approaching P/d'Arrest for attempted radar observations? P/Perrine-Mrkos appears, after erratic behavior in 1968 and unsuccessful searches in 1975, to have joined the ranks of lost comets of more than one appearance.

(3) E. I. Kazimirchak-Polonskaya: On the Capture of Comets and on the Evolution of Cometary Orbits. The classical theory for the capture of comets by Jupiter was criticized. The capture of comets by Neptune to Jupiter was presented instead as a complicated mechanism that acts in many steps lasting thousands and millions of years. The laws were described for the capture and for the evolution of orbits of observed and fictitious comets which belong to different planetary families or come from interstellar space.

(4) Z. Sekanina: Orbits and Photometric Behavior of Comets of Large Perihelion Distance. A brief review was presented of recent work by Marsden and Sekanina on the concentration in original $1/\underline{a}$ determined from comets of large perihelion distance. Discovery of more such comets for study of possible concentrations in $1/\underline{a}$ corresponding to heliocentric distances less than that of the Oort Cloud is greatly desired. The brightness of some large-$\underline{q}$ comets, including 1956 I and 1959 X, seems to change in a peculiar fashion. Comet Lovas, 1974 c ($\underline{q}$ = 3.0 AU), faded by some 5 magnitudes soon after discovery but then brightened again. Observations in 1976 indicate that the magnitude is still following an inverse square law.

(5) E. Everhart: Evolution of Cometary Orbits. Some 3×10^8 comet orbits have now been calculated in an effort to simulate the capture process of comets from near-parabolic to short-period orbits. Of recent test calculations involving more than 12,000 orbits with perihelion near the orbit of Neptune ($21 < \underline{q} < 34$ AU), only 18 led to capture, the remainder to ejection. The capture efficiency of Neptune is thus very low, 18/12,230. Capture efficiencies calculated similarly were 40/69 for Uranus, 229/500 for Saturn, and 92/229 for Jupiter, giving a final capture efficiency of 1/6000 for observable ($\underline{q} < 6$ AU) short-period comets of the Jupiter family from those in near-parabolic orbits with perihelion distance near the orbit of Neptune.

SCIENTIFIC SESSION ON SATELLITES

The session was organized and chaired by B. Morando, chairman of the Working Group on Satellites. Reports on topics concerned with observations and reductions were given as follows:

(1) E. Roemer: Follow-up Observations of Newly Discovered Faint Satellites. Searches for discovery of new satellites are normally made near opposition to facilitate identification of candidate objects. Significant fading occurs rapidly thereafter as quadrature is approached. It is necessary to verify quickly through additional observations whether a candidate object is a satellite or an asteroid, and then the nature of the orbit, whether direct or retrograde. Until the orbit can be fairly well determined, there is observational loss in limiting magnitude through the trailed images that result from inaccurately compensated motion. Loss of observations also will occur because of difficulties in obtaining time on short notice with large, suitably equipped telescopes. Weather, bright moon, and temporary unobservability arising from proximity of a faint satellite to a bright planet also will cause gaps. Coordination is essential between those who may be planning searches for discovery and those whose cooperation is needed to secure sufficient follow-up observations.

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(2) J.-E. Arlot: Problems Related to the Reduction of Observations of Planetary Satellites. The differential position of two satellites can be measured more precisely than can the relative position of satellite and primary, but O-C's of both satellites enter into the differential position. Positions measured with respect to the planet permit separation of the O-C's for each satellite and are to be preferred in spite of difficulties in getting a satisfactorily measurable image of the planet. Good determination of orientation and scale results if catalogue stars are measured and plate constant methods of reduction are used. Limb darkening introduces a serious difficulty in defining the limb of the planet, the observed phase defect being in general larger than that calculated geometrically. A phase defect error displaces the apparent position of the planet but can be partially compensated by inclusion of a longitude error of the planet as an unknown.

(3) S. Ferraz-Mello (M. Tsuchida): New Comparisons Between Sampson's Theory and Observations. Comparison of observations of the Galilean satellites made in the interval 1912-1925 with Sampson's Tables confirms earlier conclusions that the concept of the time scale (UT) of Sampson's theory is poor. Residuals are apparent for the observations 1914-1925, and have the same sense as found previously, but the indicated rate of increase with time is less than found from analysis of earlier observations made with instruments of focal length only 6-7 m.

Reports on theoretical topics were then given as follows:

(1) Y. Kozai: On the Motion of the Satellites of Saturn. The work reported was in extension of that published in 1957, in which observations made at the U.S. Naval Observatory in the interval 1928-1947 of the five inner satellites of Saturn were used to improve the elements published by G. Struve in 1930 and 1933. Some errors have been found and corrected, the theory has been extended, and new values for the masses of three satellites and for J_2 and J_4 of Saturn have been derived (in press, Publ. Astron. Soc. Japan). The source of a discrepancy between the value found for J_2 and that recommended for adoption by Commission 4 was not immediately clear.

(2) K. Aksnes (with F. A. Franklin): Analyses of the Mutual Phenomena of the Galilean Satellites. Final results from analysis of 91 light curves of mutual phenomena of the Galilean satellites in 1973 were presented. Good values were derived for the radii of JII, JIII, and JIV, and for corrections to the orbital constants of Sampson's theory, decreasing the errors to 100 km, an order of magnitude improvement over Sampson's theory. (Astron. J. 81, 464, 1976)

1 September 1976

SECOND SCIENTIFIC SESSION ON MINOR PLANETS

The following scientific reports were presented in a session chaired by President Kresák:

(1) B. G. Marsden (with contributions from Yu. V. Batrakov): The Lost Minor Planets and the Critical List. Several categories of the Critical List of minor planets were reviewed. These included (1) Those minor planets observed in only one definite opposition, almost all of which are hopelessly lost, (2) Those of unclear recent observational status, needing new investigations of orbits, (3) Those of satisfactory observational status, but requiring orbit improvements (some 300 objects are involved; only the worst cases were listed), (4) Objects with orbits expected to be satisfactory but not observed within the past ten years, (5) Planets observed in fewer than four oppositions but with recently improved orbits, (6) Objects with recently improved orbits (and in some cases new observations) that qualify for removal from the Critical List, and (7) Recently numbered objects that have not yet been observed in four oppositions. Some objects listed could already be removed from the Critical List on the basis of observations made just before the General Assembly. Particular attention was called to minor planets on the Critical List that have favorable oppositions in the near future. The usefulness of reporting

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negative searches was recognized, but observers should state the dimensions of the field searched, the ephemeris used, and the magnitude limit.

(2) J. Schubart: Present Status of Mass Determination of Minor Planets. Masses have been determined for the three largest minor planets, by Schubart for Ceres and Pallas, from their mutual perturbations, and by the late H. G. Hertz for Vesta, through perturbations in the orbit of (197) Arete during the periodic close approaches, the most recent of which occurred late in 1975. Hertz had continued to collect observations of Arete, and the number available has more than doubled from the set used in the 1968 solution. Observations of Arete in early 1977, referred to a known fundamental reference system, are of particular importance to an improved solution. A comment by J. G. Williams called attention to the possibility of obtaining additional information on minor planet masses from spacecraft tracking data.

(3) L. Kresák: Passages of Minor Planets and Comets Near the Earth. Close approaches of long- and short-period comets to within 0.15 AU of the earth during the last 300 years were analyzed to conclude, because the rate of close approaches does not increase with decrease of the intrinsic brightness, that there are probably no intrinsically very faint comets at all. Close-approach data for minor planets is obviously incomplete, most particularly because of frequently unfavorable observing conditions for discovery of Apollo-type objects. It is suggested that only a few objects observed presently as asteroids are likely to be of cometary origin. Even so, the large disproportion between the frequency of asteroidal objects and active comets permits the assumption that comets do leave small extinct nuclei of considerable lifetime.

(4) O. Møller and L. K. Kristensen: The (51) Nemausa Project. Møller reviewed the project begun by P. Naur with aims similar to those of the new project proposed by the ITA, Leningrad. Some 2200 observations of (51) Nemausa have been collected in the interval 1946-1974, many of them fully documented by information about reference stars, dependences, etc. A preliminary investigation is underway to ascertain whether the desired goal of an accuracy of $0''.03$ in the correction to the equator point, $\Delta\delta_o$, can be achieved. Kristensen called attention to a special opportunity during the 1976-1977 opposition of (51) Nemausa to tie the reference star system rigorously to the FK4, independent of errors in star positions, through observations of the minor planet against exactly the same star field on both 1976 October 25.8 and 1977 January 12.7 UT.

(5) G. E. Taylor: Occultations by Minor Planets and Satellites. Observations of occultations of stars by minor planets and satellites can give (1) Evidence for presence of atmospheres, (2) Data concerning sizes and shapes of the occulting bodies, (3) Positions of very high intrinsic accuracy, though realization may have to await improvement of star positions, and (4) Information on double and multiple star systems. Predictions, even when limited to the largest objects, face still unresolved difficulties because of (1) Errors in star positions and unavailability of positions in usable form for stars fainter than about 10th magnitude, (2) Frequently inadequate ephemerides of the occulting objects, being of highly variable accuracy for minor planets, and involving for satellites uncertainties also in the position of the planet, and (3) Impossibility of determining adequate data for the guidance of observers until improved positions of the minor planet relative to the star field can be obtained, which not infrequently is no more than a few days before the event. D. W. Dunham and J. D. Mulholland described the program of G. F. Benedict, D. S. Evans, and P. J. Shelus to predict occultations by use of a high-speed microdensitometer to scan Palomar Sky Survey glass plates for stars along the ephemeris path of solar system objects.

SECOND ADMINISTRATIVE SESSION

With the President in the chair, the proposed membership of Working Groups,

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as well as formation of a new Working Group on Prediction of Occultations, were approved as follows:

Orbits and Ephemerides of Comets: M. P. Candy, A. C. Gilmore, E. I. Kazimirchak-Polonskaya, L. Kresák, B. G. Marsden, E. Roemer (chm.), G. Sitarski, Ko. Tomita, and R. M. West.

Satellites: K. Aksnes, Yu. V. Batrakov, A. Borsenberger-Bec, C. Cristescu, S. Ferraz-Mello (chm.), Y. Kozai, J. H. Lieske, B. Morando, J. D. Mulholland, D. Pascu, E. Roemer, J. L. Sagnier, V. A. Shor, and A. T. Sinclair.

Prediction of Occultations: K. Aksnes, J. A. Burns, D. W. Dunham, P. Herget, A. Klemola, L. Kohoutek, W. H. Robertson, P. J. Shelus, V. A. Shor, and G. E. Taylor (chm.).

Establishment of an ad hoc committee to advise on the naming of minor planets, particularly those receiving numbers near 2000, also was approved, with the following membership: V. K. Abalakin, P. Herget (chm.), L. Kohoutek, B. G. Marsden, J. Schubart, C. J. van Houten, and P. Wild.

Several matters in the area of international cooperation that had been brought to the attention of the Commission already had been dealt with through one or another of the Working Groups. The cooperative observing program on minor planets described by Orel'skaya is the subject of a proposed resolution (see below).

A proposal, which had been sent to the IAU Executive Committee, for an IAU Symposium in honor of Professor Y. Hagihara on the occasion of his eightieth birthday was described by Marsden. Subject of the proposed Symposium, to be sponsored jointly by Commissions 4, 7, and 20, and to be held in or near Tokyo in May 1978, is: "Dynamical Astronomy: Theory and Application." Topics to be covered include, but are not restricted to the following: the three-body problem, planetary theory, preparation of planetary ephemerides, the Hirayama families of minor planets, the motions of satellites, and studies of the nongravitational forces acting on comets.

The President reported that a Colloquium on "Dynamics of Comets and Meteors", to be held in Bratislava under the joint sponsorship of Commissions 20 and 22 in 1980, is under consideration. Ferraz-Mello mentioned the possibility of a colloquium in Brazil, either in conjunction with the IAU General Assembly in 1979, or in 1980.

Kazimirchak-Polonskaya presented the following statement, which was warmly received by members of the Commission:

"All researchers working on the motion of comets and minor planets at the Institute for Theoretical Astronomy express their deep gratitude to Miss Professor Elizabeth Roemer for her observations, which are exceptional in their precision, for her selfless and unselfish labor.

"We wish Professor Roemer further achievements in her most useful activity.

"We are also extremely grateful to other observers, wishing them success in their important observational work."

Two resolutions in support of observational programs, the first sponsored by E. Roemer and E. I. Kazimirchak-Polonskaya, and the second presented at the request of V. I. Orel'skaya, received the approval of Commission 20:

Resolution 1

Commission 20 commends the efforts that have led recently to the discovery with powerful wide-field instruments of objects of unusual interest, including MINOR PLANETS of the Apollo and Amor types, of unusually high orbital inclination or eccentricity, or in motion commensurable with that of Jupiter; COMETS, both new ones of short period and long-period objects of great perihelion distance; and two new SATELLITES of Jupiter. At the same time, Commission 20 calls attention to the urgent need for, and great importance of, follow-up astrometric observations of these and other objects over the longest possible arc. Many of these objects are faint and the use of large telescopes with efficient detectors capable of good astrometric precision is required. Such observations are essential to the determination of reliable orbital elements upon which both future observations and studies of the dynamical evolution of these bodies can be based.

La Commission 20 reconnait les efforts qui ont abouti récemment à la découverte, à l'aide d'instruments appropriés à grand champ, d'objets d'un intérêt particulier, comprenant les petites planètes du type Apollo et Amor, ainsi que des objets ayant une grande inclinaison orbitale ou excentricité, ou ayant un mouvement commensurable avec Jupiter; des comètes nouvelles à courtes periodes et des objets à grandes periodes ayant une grande distance perihélique; enfin deux nouveaux satellites de Jupiter. Au même temps, la Commission 20 attire l'attention sur un but urgent et de très grande importance, la poursuite des observations astrométriques de ces objets et d'autres sur un arc le plus long possible. La plupart de ces objets sont faibles et nécessitent l'usage de télescopes puissants avec des techniques permettant une bonne précision astrométrique. Les observations sont essentielles pour la determination des éléments orbitaux sur lesquels seront basées les observations futures et l'étude de l'évolution dynamique de ces corps.

Resolution 2

Commission 20 endorses the following resolution of Commission 8:
"Commission 8 approves the new program (proposed by the Institute for Theoretical Astronomy in Leningrad) concerning observations of the selected minor planets for solving the problems of fundamental astrometry and asks the observatories having appropriate equipment to take part in the observations according to this program."

La Commission 20 soutient la résolution suivante de la Commission 8:
"La Commission 8 approuve le nouveau programme (proposé par l'Institut d'astronomie théorique à Leningrad) concernant l'observation de petites planètes choisies, afin de résoudre les problèmes fondamentaux de l'astrométrie, et demande les observatoires ayant les instruments appropriés de prendre part aux observations selon ce programme."

Recommendation

The following recommendation concerning the contents of the annual volume of Minor Planet Ephemerides prepared at the Institute for Theoretical Astronomy, Leningrad, was approved:

In order to make the annual volume of Minor Planet Ephemerides more suited to the current requirements of observers, the Institute for Theoretical Astronomy is requested to give consideration to the following suggestions and the possibility of introducing them into the 1979 edition:

(a) That osculating elements be derived for all numbered minor planets (except for those that are hopelessly lost) for all epochs when the Julian Date divided by 200 leaves remainder 0.5 and that each annual volume tabulate that set which corresponds to the last of these epochs falling during the corresponding year; these elements should be given with the increased precision used for the new elements introduced at the beginning of, e.g., the 1976 edition.

(b) That the lists of bright (say, to opposition magnitude 12.5) and unusual planets for which special ephemerides are prepared be extended and that the precision of these ephemerides be increased to $0^{m}.01$ in right ascension, and $0''.1$ in declination.

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(c) That the magnitudes in special ephemerides include the opposition effect with the phase according to the precepts set out by Gehrels; in the ordinary ephemerides, where the magnitude is given only for the fourth tabulated date, no allowance should be made for phase or opposition effects, and in these same ephemerides the precision of the mean anomaly should be increased to $0\overset{\circ}{.}1$; for absolute magnitudes the symbol $\underline{B}(1,0)$, rather than $\underline{g}$, should be used.

President Kresák closed the meeting with an expression to the Commission of the enjoyment and honor he had felt in serving the Commission in succession to such outstanding former Presidents as Arend, Herget, Chebotarev, and Edmondson.

JOINT MEETING OF COMMISSIONS 15, 20, and 22

The report of the Joint Meeting of Commissions 15, 20, and 22, in which highlights of IAU Colloquium 39 were overviewed, is included in the Proceedings of Commission 15.

COMMISSIONS 21: LIGHT OF THE NIGHT SKY (LUMIÈRE DU CIEL NOCTURNE)

Report of Meetings, 26, 30 and 31 August 1976

PRESIDENT: J. L. Weinberg. SECRETARY: J. G. Sparrow.

During the Assembly, the activities of Commission 21 (Light of the Night Sky) included a half day joint meeting with Commission 22 (Meteors and Interplanetary Dust), two 90-minute scientific sessions and a business meeting.

26 August 1976

JOINT MEETING

Results on Interplanetary Dust and Zodiacal Light obtained from the Pioneer 10 and 11 Deep Space Probes and the Helios 1 and 2 close-in Solar Probes

The following communications were presented during the meeting, in order of their presentation:

J. L. Weinberg: Summary of Pioneer 10/11 Results, Zodiacal Light and In situ. A new methodology was described which should facilitate the processing of the large amount of data obtained on zodiacal light and background starlight. Weinberg also summarized results from the two discrete particle detectors for R. K. Soberman, who was unable to attend.

C. Leinert: Summary of Helios 1/2 Results, Zodiacal Light. The performance of the zodiacal light photometers on both Helios probes was discussed, and preliminary results were presented based on 18 months of data received from Helios 1.

E. Grün (H. Fechtig, J. Kissel and P. Gammelin): First Results of the Micrometeoroid Experiment on Board Helios 1. Results support the findings of the Pioneer 8 and 9 dust experiments that small particles are leaving the solar system on hyperbolic orbits.

H. Fechtig: Dust Fluxes near 1 AU and in the Earth-Moon System. HEOS 2 dust experiment results were reported, including the interpretation of three categories of dust fluxes, namely random particles, fairly clustered particles (groups) and heavily clustered particles (swarms).

A. N. Simonenko and T. N. Nazarova: Space Probe Fluxes and Ground-Based Meteor Fluxes, Recent USSR Results. Read by title only.

P. M. Millman: A Comparison of Meteor Data and In situ Results. Examination of the various size ranges corresponding to different methods of observation.

R. H. Giese: The Compatibility between Optical and Mechanical Results and Theoretical Interpretations. Evidence was presented for the suggestion that the brightness and polarization of zodiacal light can be explained by scattering from fluffy, absorbing particles in the size range from a few microns to some hundreds of microns.

Brief overviews of the preceding papers and of other recent significant results were then given by F. L. Whipple, P. M. Millman and J. M. Greenberg as part of a panel discussion which concluded the joint meeting.

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30 August 1976

SCIENTIFIC PRESENTATIONS

Four invited papers and nine contributed papers were included in the scientific sessions.

G. Weill: Recent Studies of the Airglow, a Review. Results were summarized from some 170 papers published during the preceding three years.

N. B. Divari: Recent USSR Studies of the Light of the Night Sky. Read by title only.

R. Dumont: Zodiacal Light off the Ecliptic. Results were presented based on measurements made by the author in Tenerife between 1964 and 1975 (see, also, Astron. Astrophys. 51, 393, 1976).

E. Pitz (A. Schulz, C. Leinert and H. Link): Ultraviolet Observations of Zodiacal Light with the Astro 7 Rocket Experiment. Observations at elongations from 30 to 50 degrees essentially support the deviations of the color of zodiacal light in the ultraviolet from that of the sun as published by C. F. Lillie (NASA SP-310, 1972).

P. J. Edwards (G. R. Stanley and G. Neilson): Mid-Latitude Night Skylight Fluctuations of Geomagnetic and Geoelectric Origin. Mid-latitude auroral light fluctuations at 391 nm and 558 nm were studied using a cross correlation technique.

A. S. Asaad: Recent Zodiacal Light Studies at the Helwan Observatory.

Ph. L. Lamy (for M. Maucherat, P. Cruvellier, J. Maucherat, M. Hanus, M. Renard and J. P. Thouvenin): Absolute UV Photometry of the Zodiacal Light from the ELZ Instrument aboard the D2B-AURA Satellite. Preliminary results on the upper limits to the zodiacal light brightness at three bands in the ultraviolet are not in agreement with the results of Lillie or with those presented here by Pitz.

Ph. L. Lamy and J. M. Perrin: The Ultra-violet Brightness of the Zodiacal Light. Results are presented on a parametric scattering model of the zodiacal cloud that is being used to interpret results from the D2B experiment.

D. H. Morgan (K. Nandy and G. I. Thompson): The Ultraviolet Galactic Background from TD-1. Satellite Observations. Measurements of zodiacal light were also discussed. These observations should assist in resolving the question of the ultraviolet 'excess' mentioned earlier (Monthly Notices Roy. Astron. Soc., in press).

H. Tanabe: Studies of Background Starlight. A discussion was given of the Tokyo starcounting program and the comparison of these data with the background starlight results obtained from the Pioneer 10 and 11 Jupiter probes.

K. Mattila: A Photoelectric Method for Measuring the Integrated Starlight. Earlier methods used to obtain information on the surface brightness of background starlight were discussed, and a new method was suggested based on comparative measurements by two photometers having large and small fields of view, respectively.

K. Mattila: The Extragalactic Component of the Light of the Night Sky. A new method which utilizes the screening effect of a high latitude dark nebula gives $9 \pm 3\ S_{10}(B)$ for the extragalactic light at 4000A (Astron. Astrophys. 47, 77, 1976).

G. Schwehm: Temperature Distribution of the Interplanetary Dust Grains close to the Sun. These calculations take account of more recent data on particle properties than had previously been used.

31 August 1976

ADMINISTRATIVE SESSION

1. Commission Membership

The membership accepted the recommendation of the Commission officers as to the proposed new officers of Commission 21 during the next triennium:

President: R. Dumont

Vice President: H. Tanabe

Organizing Committee: A. S. Asaad, R. H. Giese, C. Leinert, Yu. L. Trutse, G. Weill, J. L. Weinberg, R. D. Wolstencroft.

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The following new members were welcomed into Commission 21: A. C. Levasseur, T. Mukai, J. G. Sparrow.

2. Commission Name

It was agreed that the French title of Commission 21 should be changed to Lumiere du Ciel Nocturne, to make it more consistent with the English title and with the current emphasis of the Commission. This change will be requested of the General Secretary.

3. Relationship to Commission 22

A similarity in part of the Reports of Commissions 21 and 22 led the General Secretary to suggest a merger of the Commissions. This similarity was primarily a consequence of the joint meeting on interplanetary dust (IAU Colloq. 31) and the inclusion of combined zodiacal light/dust experiments on the Pioneer 10/11 and Helios 1/2 probes. Techniques of the two Commissions for providing data on interplanetary dust are quite different, although complementary, and there is practically no overlap in membership due to the differences in these techniques and to the other disciplines included in each Commission. In separate meetings, the officers and membership of the two Commissions have argued strongly against a merger at this time, although joint studies and colloquia on interplanetary dust will be continued.

4. Working Group

Reactivation of the background starlight working group was agreed upon following the suggestion by Weinberg. This group is to consist of J. L. Weinberg, H. Tanabe, R. D. Wolstencroft, H. C. van de Hulst and M. Maucherat, subject to agreement by the last two people listed. The task of the working group is to survey what data are available on background starlight and the methods that can be used to separate the components; it will make recommendations to Commission 21 at the next General Assembly.

5. Other Topics

After some discussion it was decided that a newsletter to acquaint members with the availability of data from space experiments and ground based measurements would be beneficial. The incoming President volunteered to produce such a newsletter at intervals not greater than yearly from information received from members.

Meetings of interest to members of the Commission were listed, in particular the next General Assembly in Montreal, August 14-23, 1979. It was proposed to hold a Zodiacal Light and Interplanetary Medium Conference in Ottawa either before or after the General Assembly, cosponsored by IAU Commissions 21, 22, (15?) and the COSPAR Cosmic Dust Panel. The next COSPAR meeting is scheduled for Israel in June 1977.

After an interesting exchange on technical matters not particularly relevant to the business meeting, R. Dumont, the incoming President, thanked Dr. J. L. Weinberg for his extensive and enthusiastic efforts on behalf of the Commission during the past three years.

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COMMISSION 22: METEORS AND INTERPLANETARY DUST (METEORES ET LA POUSSIERE INTERPLANETAIRE)

Report of Meetings, 28 August - 1 September 1976

PRESIDENT: B.A. Lindblad SECRETARY: C.S.L. Keay

ADMINISTRATIVE SESSION

I. GENERAL

The business meeting was called to order at 10.00 on 28 August 1976. Approximately 30 members and guests were present. The President reported with regret the deaths of two commission members: Professor Astapovich of the USSR and Professor Olivier of USA. The meeting stood in silence for a few moments in their memory.

The appointments by the Executive Committee of I. Halliday as the new President of Commission 22 and of W.G. Elford as the new Vice-President, were announced. New members of the Commission, approved by the Executive Committee, were noted as follows: O.I. Belkovich, D.E. Brownlee, H. Fechtig, R.H. Giese, G.A. Harvey, D.W. Hughes, Z. Kvíz, V. Padevět, V. Porubčan and K. Tomita; bringing the current membership to 69. The President announced that the following have been asked to serve for the 1976-79 term as consulting members: V. Benyukh, E. Grün, K.B. Hindley, F. Hörz, E.P. Mazets, J.W. Rhee, J. Trulsen and D.K. Yeomans.

The following members were elected to the Organizing Committee for the coming term: H. Fechtig, C.L. Hemenway, K.N. Kramer, B.A. Lindblad, B.A. McIntosh, Z. Sekanina, A.N. Simonenko and J. Štohl.

The President reported on correspondence between the General Secretary and the Presidents of Commissions 21 and 22 relating to the subject area of Commission 21. A suggestion had been previously put forward that Commission 21 should merge with Commission 22. The correspondence had been circulated to members of the organizing committees of both commissions. There was unanimous agreement that a merger would serve no useful purpose because the observational techniques of the two commissions are so different. In a joint letter the Presidents of Commissions 21 and 22 had informed the General Secretary of this viewpoint. After some discussion at which the President of Commission 21, J. Weinberg, participated, the decision by the Presidents not to consider a merger was put to the vote and carried unanimously.

The report of the Commission had been previously circulated in manuscript to all members. The President mentioned that the subject of tectites had inadvertently been omitted from the report. The Commission gave formal approval to the report which will be printed in Trans. IAU, Vol. XVI A Part I, and distributed to all commission members.

A short discussion followed concerning the committee, established by the Meteoritical Society, on meteorite nomenclature. It was agreed that the President of Commission 22 should continue to serve as a consultant to this committee.

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Following a brief discussion of the report of the committee on Radar Observations of Meteor Rates and Radiants and Anomalies at the Base of the Thermosphere, it was agreed that the committee be expanded by the addition of the following new members: O.I. Belkovich, I. Halliday and J. Jones.

The Vice-President, I. Halliday, expressed the thanks of the entire Commission to the retiring President for his work on behalf of Commission 22 during the past three years, particularly for the preparation of the Report of the Commission and for arranging the sessions at the General Assembly.

I. Halliday issued an invitation to a symposium (or colloquium) on the subject of meteors and interplanetary dust to be held in Ottawa immediately before, or after, the 1979 General Assembly in Montreal. It was hoped that the meeting would be co-sponsored by IAU Commission 21 and the COSPAR Cosmic Dust Panel. The majority of those present favoured a meeting to follow the General Assembly in 1979.

II. RESOLUTIONS

The following resolutions were proposed and carried without dissent; a preliminary text of Resolutions 1 and 2 had been circulated to members of the Commission prior to the business meeting.

1. Commission 22 recommends that a cooperative long-term program of radar observations of meteor showers from several points on the earth be initiated with the aim of studying meteor stream cross-sections and longitudinal structure.

2. Commission 22 recommends that a meteor data centre in Lund, Sweden be established for the collection of meteor observations by radio and photographic techniques. The Commission expresses the hope that sufficient financial support will be forthcoming to ensure the operation of such a data centre.

3. Commission 22 notes with interest the programme for Fireball Photography initiated by the B.A.A. and the operation of an International Centre for Meteor Observations for the collection of visual meteor data. The Commission appreciates the value of these programmes and endorses their continuing operation. The commission expresses the hope that sufficient financial support will be forthcoming to ensure continued operation.

4. Commission 22 approves the Progress Report by the "Committee on Radar Observations of Meteor Rates and Radiants, and Anomalies at the Base of the Thermosphere" established at the XV IAU Congress. The Committee is requested to continue its efforts to develop a widely acceptable design for an economical Meteor Rate-measuring Radar System.

5. Commission 22 wishes to call to the attention of observers with access to fast, wide-field telescopes the importance of searches for comet anti-tails. The Commission notes that the association of meteor streams with short-period comets is well established from other studies, however, the observation of anti-tails provides in a more direct way evidence concerning the separation of large dust particles from the nucleii of short-period comets. Owing to special geometrical circumstances and the general faintness of short-period comets, this information is generally lacking.

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SCIENTIFIC SESSIONS

25 August 1976

A half day of discussion was devoted to the topic "The Future of Photographic Meteor Programs". The focus in this session was on photographic fireball networks and meteorite recovery projects. It was noted with regret that the Prairie network fireball program had been terminated. The opinion was expressed by several speakers, that the fireball orbits obtained in the Prairie network program were of an exceptional accuracy and that as many orbits as possible should be fully reduced and published. It was noted that several new photographic fireball networks are presently being put into operation. The wide interest in this field was demonstrated by the reports presented at the meeting. The technical and personnel problems of operating a fireball network over an extended period of time were discussed. It was recognized that a fatigue problem could arise if no meteorite was recovered early in a program.

The following reports were presented:

F. Whipple: Observational Problems in Meteor Photography.

F. Whipple and R. McCrosky: Some Results of the Prairie Network Project.

I. Halliday: MORP - The Meteorite Observation and Recovery Project.

K. Hindley: The British Fireball Network.

J. Kiko: Reliability and Efficiency of the European Meteorite Camera Network: The German Part.

Z. Ceplecha: The European Fireball Network, Some General Remarks.

V. Porubčan: The Czechoslovakian Fireball Network: The Slovakian Part.

A.N. Simonenko and V.V. Fedynsky: The Soviet Bolide Network. (Read by O.I. Belkovich).

P.B. Babadzhanov: Combined Photographic and Radar Observations of Meteors at the Dushanbe Astrophysical Institute.

P. Millman: Electronic Image Intensification in Meteor Photography.

26 August 1976

This session was a joint meeting with Commission 21. Its purpose was to present recent results on Interplanetary Dust and Zodiacal Light obtained from the Pioneer 10 and 11 Deep Space Probes and the Helios 1 and 2 close-in Solar Probes. The following communications were presented:

J.L. Weinberg and R.K. Soberman: Summary of Pioneer 10/11 Results, Zodiacal Light and In Situ Measurements.

C. Leinert: Summary of Helios 1/2 Results, Zodiacal Light Measurements.

E. Grün: Summary of Helios 1/2 Results, In Situ Measurements.

H. Fechtig: Dust Fluxes near 1 AU and in the Earth-Moon System.

P.M. Millman: A Comparison of Meteor Data and In Situ Results.

R.H. Giese: The Compatibility between Optical and Mechanical (In Situ) Results and Theoretical Interpretations.

After these presentations a summary discussion followed with contributions from J.M. Greenberg, P.M. Millman and F.L. Whipple. The reader is referred to the minutes of the sessions of Commission 21 for further information.

28 August 1976

A half day of discussion was devoted to visual and radar techniques. Short papers were presented at this session as follows:

C.S.L. Keay: On Radar Observations of Meteor Rates and Radiants, and Anomalies at the Base of the Thermosphere: Report of IAU/IAGA Joint Committee.

J. Jones: On the Determination of the Meteor Radiant Distributions from Single Station Observations.

B.L. Kashcheev and V.Z. Nechitajlenko: Automatical Radar System for the Study of the Cosmical Nature of Meteors and Their Penetration into the Earth's Atmosphere. (Paper read by O.I. Belkovich).

K. Hindley: An International Centre for Amateur Meteor Observations.

F. Link: On the Presence of Cosmic Dust in the Upper Atmosphere.

B.A. Lindblad: Meteor Radar Rates and Solar Activity.

P.B. Babadzhanov: Winds in the Upper Atmosphere.

K. Tomita: Japanese Meteor Radio Program.

V. Padevět: Effective Dynamic Cross Section of a Meteor.

1 September 1976

This session was a joint meeting with Commissions 15 and 20. The meeting highlighted some of the results presented at the IAU Colloquium No. 39, Lyon 17-20 August 1976. The meeting was organized by A.H. Delsemme. The reader is referred to the minutes of the sessions of Commission 15 for further information.

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COMMISSION 24: ASTROMÉTRIE PHOTOGRAPHIQUE (PHOTOMETRIC ASTROMETRY)

Report of Meetings, 28 August 1976

PRESIDENT: P. Lacroute SECRETARY: M. Creze

First Meeting: 9 H 15

The president announced that, as a result of the postal ballot of the members of the commission, the following names were proposed for the new officers and the organising committee, for approval by the general assembly: President, C.A. Murray; Vice-President, H.K. Eichhorn; C.O., De Vegt Ch., Fredrick L.W., Gliese W., Harrington R.S., Lacroute P., Potters M.J., van Altena W.

The following were confirmed as new members and consultants of the commission:
New members: Firneis M.G., Gatewood G., Ianna F.A., Hershey J.L., Hill G., Jones B.F., Jones D.H.P., Latypov A.A., Nicholson W., Onegina A.B., Podobed V.V., Robertson W.H., Valbousquet A.
Consultants: Cudworth K., Hanson R.B., Kanaev I.I.

DISCUSSION ON THE REDUCTION OF RELATIVE TRIGONOMETRIC PARALLAXES TO ABSOLUTE VALUES

W.F. van Altena, E.D. Hoffleit and H.A. Smith, Yale University Observatory, presented by W.F. van Altena

Abstract

Systematic differences in trigonometric parallaxes between Allegheny Observatory and Yale Observatory, between Allegheny Observatory and McCormick Observatory and between the Cape Observatory and Yale Observatory have been investigated for stars common to each pair. The differences found correlated with right ascension, naturally suggesting some sort of annual influence. It is proposed that these differences are related to differences in the annual temperature cycle between observatories, possibly through the mechanism of temperature dependent decentering of the telescope objectives. A dependence upon spectral type was also discovered in the differences between the relative parallaxes from Allegheny and from Yale. Further work is needed to clarify the nature of these systematic effects and to insure that they do not significantly bias available trigonometric parallaxes.

It is proposed that a new parallax catalogue be constructed at Yale after a thorough statistical analysis of all available trigonometric parallaxes has been made. We solicit suggestions and recommendations from interested users.

C. TURON, M. CREZE, PRESENTED BY M. CREZE

Given a sample of trigonometric parallaxes, it is assumed that:

1) - There is the possibility of defining, from photometric or spectroscopic observations, a number of subsets, in each of which all stars may be assumed to have about the same unknown absolute magnitudes.

2) - There exists a partition of the sample such that in each part the systematic errors of trigonometric parallaxes may be considered to be identical.

Then a method is proposed by which all kinds of suspected systematic errors in trigonometric parallaxes may be derived together with absolute magnitude calibrations. The method provides absolute systematic errors, and not only

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systematic differences between catalogues.

Details will be published soon in Astronomy and Astrophysics.

PROBLEM OF THE HYADES

In a short report, W.J. Luyten announced many new measures of plates on the Hyades and Pleiades fields and new proper motions.

Hanson reported on the proper motions in the Hyades.

Afterwards some remarks on the importance of the parallaxes of the Hyades were made.

DISCUSSION

P. Connes: Do members of the commission believe that an instrument able to measure relative parallaxes free from any instrumental effect and with quite negligible random errors, could provide an important contribution to the problem of trigonometric parallaxes?

K. Aa. Strand: A special astrometric facility has been designed by a study group at NASA-Ames this past summer, with the aim of obtaining accuracies of the order of one tenth milliarc second.

W. van Altena: Due to the importance of systematic errors in the study of trigonometric parallaxes it is very important that observations be made with several different instruments. I would strongly urge you to develop an instrument to determine very accurate relative parallaxes.

<u>Second Meeting: 11 H 15</u>

IMPROVEMENTS IN PHOTOGRAPHIC ASTROMETRY

A.R. Klemola

Second-epoch photography for the proper motion program continues with the completion of 685 of the total of 1246 fields lying at declination -20° and northward. The plate measurements, devoted to those fields lying outside the zone of avoidance, have been completed for a total of 190 fields at +25°, +30°, and +35°. Reductions for proper motions, positions, and photometry have been carried out for a group of overlapping plates around the north galactic pole. The average annual rate of measurement comes to about 150 fields per year.

Reductions based on galaxies as a reference frame call for the use of a model, which includes additionally the cubic terms x^3, x^2y, xy^2 in x and y^3, x^2y, xy^2 in y, for the satisfactory reduction of residuals locally over the plates. Moreover, we find that the coefficient of the radial distortion term has changed significantly between the first and second epoch plates and must be included in the reduction for proper motions. It is found that on a 6° x 6° field there are possible local systematic residuals over small areas of one or two degrees which reach two microns or more. This represents a limit to local systematic accuracy of about 0.5 to 1.0 arcsec for proper motions as evidenced from a comparison of overlapping plates where images are of poorer average quality.

External comparisons of a preliminary nature have been made with the AGK3 for the sample of overlapping fields around the north galactic pole. It is clear that a strong magnitude equation in one of the proper motion sources exists when differences AGK3-Lick are formed separately for stars brighter than and fainter than magnitude 9. These differences are well in excess of the amount expected for the correction to precession in this part of the sky. The study of these differences

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in proper motions continues with the more extensive data available for the +22° to +38° zone.

The sky brightness at Mt. Hamilton, now increasing at a rate of 5% per year, is becoming an important limitation for long exposures with the astrograph. The need for eventual transfer of the astrograph to a dar-sky site is indicated.

DISCUSSION

C.A. Murray: Are the proper motion differences in the overlapping regions more in R.A. or in declinations?

A.R. Klemola: It is the same in both coordinates.

S. Vasilevskis: Do the systematic errors mentioned by you affect mean proper motions of stars distributed over the whole plate?

A.R. Klemola: The differences in proper motions include the effects of precession for this point of the sky. Therefore the large differences in Lick and AGK3 represent errors of systematic nature as well as precession.

CORRECTION OF ERRORS IN THE LOWER PART OF AGK2 NEW REDUCTIONS

P. Lacroute and A. Valbousquet

Summary

Paper to be published in Astronomy and Astrophysics.

Some difficulties in the reduction of AGK2 below +20° by the overlap method suggest the necessity of a new reduction. The authors have established that there are important systematic errors in the measures of AGK2, of about 0".1 on the average, but often as large as 0".30. These errors, which are different for different zones of declination, are the cause of the difficulties in the resolution and give systematic errors in the mean results, which sometimes amount to 0".10.

After correction of the data the systematic errors are progressively eliminated.

Taking into account these difficulties, a new solution of the AGK2 has been obtained by a method giving more emphasis to the reference stars and less to the comparison between the stars. That slightly improves the agreement with the reference stars but diminishes the agreement between the plates. A check shows that in the ne solution the systematic differences between the photographic positions and the reference positions are not significant.

Remark by W. Dieckvoss: In 1960, in Hamburg, we took the "screw-error" of Bonn's machine (decl. +7°.5; +5°.0; +2°.5; 0° ; -2°.5) at face value. The discussion of the "field errors" showed no indication of residual screw error (now determined to be as large as 0".16, original curve at Bonn, 0".4 . . . 0".5). This gives rise to larger mean errors without affecting the overall system (FK4).

ASTROMETRIC POTENTIALITIES OF A NEW FOUR-FOLD COVERAGE OF THE NORTHERN HEMISPHERE

Chr. de Vegt, presented by W. Dieckvoss

During the Perth Symposium the project of a new fourfold coverage of the northern hemisphere including a completely new reduction of the whole AGK2 plate material was discussed (1,2). In the meantime detailed results from the new zone astrograph have confirmed the high accuracy of the instrument (3).

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Expected Results from 4-Fold Coverage in Comparison with AGK2/3 Data

Catalogue		Epoch(s)	M.E. of Pos.	P.E. of P.M.	Source Cat.
AGK3	(1)	1960	0".18 - 0".26+	about 0".01/a	(1)-(2)
AGK2	(2)	1930	0.15 - 0.22+		
4-fold coverage	(3)	1975 adopted epoch	0".07		
AGK2N AGK2 - new reduction	(4)	1930	0".14	0".004/a	(3)-(4)
Carte du Ciel final reduction	(5)	1891 - 1950	0".14 - 0".20	0".002 - 0".003/a	(3)-(5)

+dependent on magnitude, see (3).

An important step in the formation of the new catalogue is the complete remeasurement of the AGK2 plates including both exposures. Magnitude dependent errors can then be reduced and recently found discrepancies in the Bonn-zone of the AGK2 (4) could be fully removed.

The suggested catalogue project will provide a homogeneous system of positions and proper motions up to m_V = 12-13. Therefore a high-density 2nd-order reference system is obtained and a large number of faint reference stars for a final reduction of the CdC will then be available.

From the remeasurement of the AGK2 plates the present AGK2/3 solution can be improved considerably.

With a view to the suggested ESA space mission (5) the new catalogue will provide a homogeneous net of stellar positions for a detailed comparison of groundbased and spaceborn astrometric data.

References

(1) de Vegt, Chr., IAU Symp. 61, 209 (1974).
(2) de Vegt, Chr., Ebner, H., MNRAS 167, 169 (1974).
(3) de Vegt, Chr., Mitt. Astron. Gesellsch. 38, 181 (1976).
(4) Lacroute, P., Valbousquet, A. (to be published).
(5) European Space Agency (ESA), Space astrometry, report on the mission definition study, Neuilly (1976).

DISCUSSION

P. Lacroute: Some difficulties may arise with the overlap method if the material has systematic errors on the plates. It is difficult to know to what extent some large observed differences between the simple reduction and the overlap reduction come from the systematic errors in the initial data or from the overlap method.

R.B. Hanson: I agree that good plate material is necessary for the overlap reductions, since the R.M.S. dispersion of the proper motion differences across plate gradient boundaires is equal to that expected by applying the precepts of

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Eichhorn and Williams (1963. A.J. 68, 221) i.e. 0".005/year. There is no direct implication in Hanson's finding of deficiencies in the plate material, only in the lack of proper overlap reduction.

RESOLUTIONS

A first resolution presented by Murray endorsing the collaboration between Denmark and the United Kingdom for operating the automated Carlsberg Meridian Circle was adopted. This resolution was also submitted to commission 8 and has been adopted in its final form at the end of the joint meeting of Commissions 8 and 24, on Monday 30 September.

A second resolution was proposed by van Altena to give support to the compilation of a new general catalogue of trigonometric parallaxes. This last resolution provoked the following discussion:

K. Aa. Strand: I am not in favour of having a catalogue produced on the basis of the paper presented this morning by Dr. van Altena.

W. van Altena: The present investigation is quite preliminary and is based on a small amount of material. It is hoped that a complete investigation of all available relative parallaxes will make it possible to isolate the source of the systematic errors. It is unlikely that the wholesale remeasurement of old parallax plates will result in an overall systematic change in the parallax system of any one observatory. Since the old parallax series were only exposed to obtain a mean reference frame at about 11th magnitude, there are in general not enough reference stars to model potential nonlinear field effects in the coordinates.

W. Gliese: The enormous work of trigonometric parallaxes especially at U.S. Naval Observatory and the large amount of new photometric distance determinations of faint red dwarfs make it desirable to compile a third catalogue of nearby stars within the next three years. The last catalogue, in 1969, was compiled without applying any corrections at all to the various parallaxes though we did not feel very happy about this. Therefore, I support van Altena's proposal to establish a uniform system of trigonometric parallaxes in the near future.

S. Vassilevskis: I would like to express appreciation for the readiness of Yale University Observatory to prepare a new catalogue.

K. Aa. Strand: Instead of a resolution I propose that the commission organize a working group on the subject.

W. van Altena: It will be necessary to have close cooperation with all parallax observatories if reliable corrections are to be determined. Observing and measuring procedures as well as temperature gradients may be required in order to understand the systematic nature of the corrections. I plan to work closely with all observaories in the derivation of the corrections and see little value in establishing a working group since all likely members would be involved in the project at the appropriate time.

L.W. Fredrick: At the McCormick Observatory we considered the question of making a new parallax catalogue and concluded that now is not the time to compile this catalogue.

W. van Altena: It is more than 25 years since the closing date of the Jenkins parallax catalogue and 14 years from that of the supplement. Since that time only the U.S. Naval Observatory has been a major producer of parallaxes and this situation is not likely to change in the near future. New observing techniques such as space astrometry and ground based photometric and interferometric instruments are not likely to have any impact on the field for at least the next 10 years, since

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no such operating instruments exist now and the space experiments will only be launched in 1983 at the very earliest. For these reasons, I can see no persuasive argument for delaying a new parallax catalogue when numerous astronomers have expressed a strong desire for one that deals with the problem of the systematic errors.

P. Lacroute: I propose that further discussion on van Altena's resolution be adjourned until the end of the joint meeting of Commissions 8 and 24. At the end of this last session, van Altena's resolution was adopted by a big majority in the following form:

Recognizing the fundamental importance of trigonometric parallaxes for the establishment of the galactic distance scale and the calibration of stellar luminosities, and noting that the Yale general catalogue of trigonometric parallaxes is now more than twenty-five years old, Commission 24 recommends that a new general catalogue be compiled in consultation with interested individuals, and that every effort be made to derive an uniform system of absolute parallaxes.

C.A. Murray read a letter from Professor J. Meurers suggesting that a colloquium on "Modern Astrometry" be held in Vienna in 1978. Commission 24 agreed to sponsor such a colloquium.

COMMISSION 25 : PHOTOMETRY AND POLARIMETRY (PHOTOMÉTRIE ET POLARIMÉTRIE STELLAIRES)

Report of Meeting, 30th August 1976

PRESIDENT : M. Golay

1 - Colour Equations B and V Photometry

By Ivan R. King

The most widely used photometric system, photographic B and V, has serious systematic problems that are not generally recognized. The photographic sensitivity bands do not match well with the corresponding photoelectric sensitivity bands ; and as a result, the photographic systems each have a colour coefficient of the order of 0.1 (B-V) with respect to the photoelectric systems. These colour coefficients are serious, they are poorly known, and they are usually ignored.

Colour coefficients can be calculated theoretically from known flux curves and "known" sensitivity functions ; they predict a strong coefficient for V and a smaller one for B.

The empirical determination of colour coefficients is difficult, and in fact the usual photoelectric calibration sequence does not allow a colour calibration at all. The curve is drawn through the points, and there are no useful residuals. The only useful residuals come from redundant photoelectric observations, where stars of different colour are observed at the same magnitude. Each such group of stars has an unknown zero point, but they should all have the same slope against B-V, which can be found from a least-squares solution over all the groups. I have made such a solution from careful calibrations in SA 51, 57, and 68. My overall conclusion is that in wavelength the photographic B and V stand "outward" of the photoelectric B and V points, each by about 0.10 (B-V), with an uncertainty of ± 0.03 in each coefficient. For V, the sensitivity curves make it obvious that this should be so ; but for B it is hard to understand.

The M dwarfs have a special problem, because of TiO bands that affect the V photographic passband much more than the photoelectric. As a result (confirmed both by calculation and by observational data) the dwarf M's deviate from the linear colour equation by amounts that may exceed a tenth of a magnitude.

Comments

By A.N. Argue :

I would like to make two comments :

1) The (U-B) colours of late type giants are considerably different from the main sequence. So could a term in (U-B) be included in the colour equation to take care of the differences you mentioned between giants and main sequence ?

2) It might be dangerous to derive the colour equation only from the "bright stars" because of the existence of the so-called "photographic Purkinje effects". The relation between brightness and measured density for an in-focus photographic image

is a very complicated function of intensity, wavelength and other factors. For a refractor you also have the chromatic aberration, but the dependence of colour equation on brightness level can also operate for a reflector.

By Willstrop :

Twenty years ago the UBV system was introduced to avoid the systematic errors in m_{pg} caused by the Balmer discontinuity. It seems that we should now try to eliminate the red end of the V_{pg} response function.

By A.W.J. Cousins :

At Dr. Velghe's request (he is at present in Cape Town) I wish to draw attention to the VRI sequences now available in the Harvard E and F regions and in the Magellanic Clouds. (Mem.R.Ast.Soc. 81, 25 and Mon. Notes Astron.Soc.S. Africa, 35, 70 (1976)). Some hundreds of bright southern stars, a fair number in the equatorial zone, have also been measured, luminosity sequences have been established and the reddening locci determined. Unpublished material can be supplied on request.

2 - Photoelectric magnitude sequences in the yellow and the near infrared

By J. Denoyelle and A.G. Velghe :

In the study of galaxies one of the major problems is the evolutionary process of the disk. Unravelling this evolution requires the collection of many small bits of information. The suggestion I am going to make aims to provide such a bit of information. The problem we want to tackle is : "Are there differences in the large-scale distributions of the objects composing the disk, and if so, are they related to differences in age and evolution ?"

Obviously the first step is to obtain reliable distributions for the disk-components ; therefore, we need space-densities up to very large distances from the sun and also as a function of the distance to the galactic plane. This in turn supposes that the objects to be studied are easily detectable and classified. As Baade discovered, the main contributors of the disk-population are red giants, the M-type giants in particular.

Thanks to the effort and the impulse of J.J. Nassau, classification criteria have been established by him and his associates, for stars of the type M, C and S, based on the aspect of objective prism spectra in the near infrared : the wavelengths region extends from 6800 to 8800 A. These classification techniques were summarised by Nassau and Velghe (1964).

As has been shown already by Blanco (1965), it is possible to adopt natural groups for stars later than M1 :

the group M2-M4	: TiO 7054A	: strong/7589A : moderate/8432A : absent
M5-M6.5	: 7589A	: strong/8432A : visible/VO7900A: absent
M7 and later:	VO7900A	: present.

It seems however rather hazardous to separate stars with types M5 and later in two different groups, because the spectra of many of these stars vary within this range during a cycle of light variation. Moreover, statistical studies have indicated that the space distributions are very similar within the range of the group M2-M4 (early type M stars) and the group M5-M10 (late type M stars). When surveys

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of M-stars are made, a most interesting byproduct is the detection of S stars and Carbon stars. The more of these stars are found the better the question can be answered how these objects are distributed and what their affinity is with one or another population group.

From the infrared objective prism spectra a sufficient number of M stars is obtained, so that reliable information on their space-distribution can be derived by the method of star counts. Moreover, the problem of interstellar absorption can be solved, provided the apparent distributions are available in two magnitude systems, for instance in yellow (Johnson's V) and infrared (I). For the details of this method, the reader is referred to the paper by Velghe (1972).

It is evident that the precision of this true distribution depends on how good the observed distributions are : this means that the statistical irregularities must be small and the errors in the magnitude scales negligible. With the large Schmidt telescopes now available, the statistical conditions can be matched for objects up to an infrared magnitude of say $m_i = 14.0$ at least. Due to the colour indices of these cool stars the yellow magnitude limit lies around 16.5 or 17. Of course the only reasonable way to determine the magnitudes of hundreds of stars is by photographic photometry, which in turn requires the availability of photoelectric standard sequences.

As stated in the very beginning, this investigation concerns the disk-population as a whole and therefore a larger project should be programmed. In our view, spectral surveys in the near infrared should be undertaken in a large number of regions, well distributed in galactic longitude, as well in the galactic plane as at different latitudes up to intermediate heights. As the frequency of these objects diminishes quite rapidly with increasing latitudes, one should concentrate first on the galactic plane and the lower latitudes. At the center of these regions, a sequence of about 20 intermediate to late type stars should be measured photoelectrically in the yellow and the infrared. It might be possible to use stars already identified as late type stars.

These sequences are needed as standards for photographic photometry and should be set up very carefully : requirements are principally that they go deep enough in the yellow magnitude (V = 16.5 at least), as to allow the determination of colour-indices for the fainter stars ; secondly the effective wavelength of the photoelectric and the photographic magnitude systems should correspond as closely as possible to avoid the annoying problem of the colour-equation.

At first sight this seems a non-realistic programme, as it sounds like the special plan of selected areas. However, the situation is far more comfortable : 1) the number of stars per region is quite low ; 2) some areas can be included, that are used for other investigations, such as Harvard Standard Regions, Mc Cormick Areas ; 3) the fast photometric techniques now currently used in connection with telescopes of the one meter size, allow a rapid execution. We estimate that the whole project could be terminated within a couple of years. The only condition is that at least some members of this Commission support this proposition and are willing to contribute to such a programme by making some observations.

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J.J. Nassau and A.G. Velghe	1964, ApJ 139, 190
A.G. Velghe	1956, Astron.J. 61, 241 (communic. Obs. Roy. Belgique No 104, 1956)
A.G. Velghe	1972, Symposium on the New Astronomy, Bloemfonteim

South Africa (= Communic. Obs. Roy. Belgique
Series A No 25)

Comments

By P.S. The

1) It is indeed of great importance to study the space density of M giants as function of galactic longitude and latitude, since this information can be used for the study of the evolution of our Galaxy.

2) The study of the space density of the M giants was started long ago by the late Dr. Nassau. Astronomers contributing to this study are Van Albada, McCuskey, Blaauw, Westerlund, Hidajat, Mavridis, Vluming and Thé (McCarthy adds : Blanco, Cameron, Seyfert, Mac Rae, Allers, Sanduleak, Pesh, McConnell, Philips, Stephenson). An excellent review of the work done up to 1970 was published by Mavridis in "Structure and Evolution of Galaxies", Reidel Publ. Co., 1971. Up till now the situation of the programme in the galacitc plane is that, except 2, all 15 luminosity function fields (LF-fields) of Dr. McCuskey has been studied for the space density of M giants.

3) In order to avoid all kinds of difficulties in combined photoelectric photographic photometry I measure directly the M giants photoelectrically in Kron's R, I-system. This is only possible if we are studying fields fairly far off the direction of the galactic centre, and off the galactic plane, in which the number of M giants is not large.

4) To expedite the work I would like to propose to combine forces.

Reply to the comments of Dr. P.S. The

After the private discussions I had during this assembly, I certainly agree to coordinate first the available information.

We do not propose the R-system because of the poor matching of the photographic and the photoelectric system.

3 - A catalogue of photometric sequences

By A.N. Argne and E.W. Miller : Supplement No 2

An account will be published in the Proceedings of I.A.U. Colloquium No 35 : "The compilation Critical Evaluation and Distribution of Stellar Data", Strasbourg, France, 1976 August 19-21.

I trust no further account is needed for the report of Commission 25, but please let me know if you require an abstract.

4 - Discussion of V magnitude for uvby system

By Ch. R. Tolbert

Since about 1970, we have had a set of standard stars available for the uvby system (Crawford and Barnes, A.J. 1970). Unfortunately no homogeneous standard magnitudes are available for these stars. I would like to urge that this commission

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recommends the establishment of Y and/or Johnson V magnitudes for the standard stars now being used in the uvby system.

Comments

By A.W.J. Cousins

We have never experienced any problems in reproducing V magnitudes (with different filters, photocathodes, refractors and reflectors) and they correlate quite well with the Strömgren y (except for late type stars). I am not aware what problems Dr. Tolbert has encountered.

By F. Rufener

It should be noted that the V magnitudes that we determine in the Geneva Photometry (UBV B_1 B_2 V_1 G) is equivalent to the one in the UBV system of Johnson-Morgan.

The second catalogue of stars measured in the Geneva Observatory Photometric System which is in press (Astron. Astrophys. Suppl. 26) already contains 206 stars on the 319 which are shown as standard stars in the tables II and III of Crawford and Barnes (AJ, 75, 978). The remaining 113 stars from these lists are still being observed. About thirty of them already have correct V magnitude estimations in the Geneva System.

5 - Magnitude in the photometric catalogue of Geneva

By F. Rufener

After the accurate measurement of the six colour indices, an apparent V magnitude has been determined for the stars of the photometric catalogue of the Geneva Observatory.

Rufener and Maeder (1971, 1973) have described the method utilized for the creation of a standard stars sequence which constitute the basis of this V magnitude scale. Prepared independently of the Johnson and Morgan scale, the zero of this new scale has been fixed in such a way that they correspond to each other. Through an examination of the correlations between these two scales, it has been found that, for most of the uses, the two definitions were identical and therefore the V magnitudes of the two systems interchangeable. However, we always have isolated the determinations done in Geneva and we have never mixed or averaged our measurements to those of the UBV system.

The determination of an independent V magnitude has been done, for each measurement of star, in seven colours. A weight related to its quality has been attributed to each of these determinations, independently of the weight given to the colour indices. For each star, we have calculated a weighted mean of the V magnitude and a corresponding standard deviation. We have, under publication (Rufener, 1976), a catalogue of 4670 stars containing, in addition to the six colours of the Geneva photometry, a V magnitude accompanied by a standard deviation (σ_V) and by the number (Q) of the good measurements which have defined this mean. The σ_V calculated for the values of $Q \leqslant 5$ is statistically not significant ; however it indicates clearly that an anomaly of stability may occur when $\sigma_V \geqslant 0.020$. When the value of $\sigma_V \leqslant 0.015$, this simply indicates the good agreement of the determinations, but is not a proof of great stability or great precision. On the other hand, when $Q > 5$, σ_V becomes significant. Its typical value for stable stars, easy to measure and which have often been observed, is $\sigma_V = 0.011$.

In Table 1, we have defined the criteria that were chosen to characterize A) the cases where the star is considered as variable or microvariable quasi certain and, B) the cases where this conviction is still very probable, say two chances out of three.

We have at present a compilation of 35'000 measurements in seven colours related to more than 7'000 stars and the observations are carried out in the Northern sky as well as in the Southern sky.

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Rufener, F. 1976, Astron. Astrophys. Suppl. 26, 3, in press.

TABLE 1

CRITERIA OF VARIABILITY OR OF MICROVARIABILITY

Number of measurements Q	Standard deviation for the V magnitude ($\sigma_V.10^3$)	
	Criteria A	Criteria B
6 - 10	$\geqslant 25$	$\geqslant 19$ < 25
11 - 20	$\geqslant 19$	$\geqslant 15$ < 19
> 20	$\geqslant 15$	

6 - A note on photometry of faint stars

By H.R. Butcher ; paper presented by B.J. Bok

Members of IAU Commission 25 may be interested in a recent experiment comparing stellar photometry from photographic plates with measurements from electronic camera exposures.

The experiment compared electrographic measures of stars in NGC 1866, reported by Walker (M.N.R.A.S. 169, 199, 1974), and photographic measurements of the same stars on Kodak emulsions type IIIaJ and 127-04. The electrographic data were obtained with a Spectracon type electronic camera, and consist of multiple exposures in the V band of the UBV system, taken with the 1.5 m reflector on Cerro Tololo. The photographic material consists of one 45 min., sky limited IIIaJ plate (with a GG 385 filter) and one 65 min., sky limited 127-04 plate (with a GG 495 filter). These plates were obtained by the writer with the 4-m reflector on Cerro Tololo.

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Because the methods of reduction of the two sets of data were different, they should be described briefly : Walker used a density-recording microphotometer to make a single scan across each stellar image. He then measured the area under each profile, and converted this area to a magnitude (cf. ApJ, 161, 835, 1970). The writer, on the other hand, has used a digital microphotometer to record a square raster pattern for a part of each of his plates, the interval between points being ten microns. Each data point has been subsequently converted to an intensity reading, using spot calibrations recorded on each plate simultaneously with the stellar exposures. Next, the centre of each image was found (to an accuracy of 2-3 microns) and the intensity readings were then plotted as a function of distance from this centre. A standard stellar profile was then fitted to this plot of data points, and the resulting calculated "volume" under this profile was converted to a magnitude. Measurements from both the IIIaJ and 127-04 exposures were combined finally to derive a V magnitude, using an equation of the form V = m(127) + a . m(IIIaJ) - m(127) + b, where a and b are constants whose values were determined by a least-squares fit to Walker's measurements.

It has been found that many of Walker's stars are not single, and that agreement between the photographic and electrographic magnitudes is worse for the blended images. There is also poorer agreement for stars closer than 2.5 arcmin to the centre of the cluster, an effect probably due to an increased background of faint stars.

The attached graph shows a comparison between the photographic and electrographic V magnitudes for single, unblended images farther than 2.5 arcmin from the centre of the cluster. It would appear that over a range of at least four magnitudes, the photographic results compare very favorably with the electronic camera data. Any non-linearity in the photographic magnitude scale is clearly only a few percent over the whole range, if there is in fact any non-linearity at all.

For the range of magnitudes $18.5 < V < 22.5$, Walker estimates his average probable error to be $\pm$ 0.06 magnitude. For the restricted group of stars the scatter of the points is less than this estimate ! A similar plot comparing all unblended images of Walker's stars (25 objects) yields a scatter of $\pm$ 0.06 mag (p.e.), and one for all the stars faint enough to have unsaturated images ($m > 19$, 55 stars total), blended or not, yields $\pm$ 0.08 mag (p.e.). The real accuracy of the derived magnitudes, of course, depends as much on precisely what is measured, and on how it is measured, as on the information content of the plates, a point noted by Walker as well. But it does appear that the photographic results compare remarkably well with the electronic camera data.

There are several factors which are believed to have contributed to the success of this experiment. First, of course, is the high quality and fine grain of the IIIaJ and 127 emulsions. Next is the recording of spot calibrations on the same plates as were used for the stellar exposures. And finally, credit must go to the Photometric Data Systems microphotometer employed in the reductions, which has close to one micron positional accuracy and can record densities up to ~ 5.0.

The actual reductions reported here were performed at the Kitt Peak National Observatory, Tucson, with the Kitt Peak PDS microphotometer, CDC 6400 computer, and interactive picture analysis facility. The necessary computer programmes were written by E. O'Neil, P. Scott, D. Wells and especially C.R. Lynds. Similar efforts, using slightly different methods, have recently been reported by Kinman (Observatory, 95, 280, 1975 : paper read by Clube).

7 - The ESO-SRC Southern Sky Survey

By R.M. West and R.D. Cannon

In response to many requests from IAU participants, we would like to summarise the current state of the ESO-SRC Southern Sky Survey.

This is the main survey to be carried out by the ESO 1 m Schmidt telescope in Chile and the UK 1.2 m Schmidt in Australia. The ESO Schmidt has now almost completed the preliminary ESO(B) "quick blue" Survey, on Eastman Kodak IIaO emulsion, and film and glass copies have been widely distributed. It will soon commence the deep red survey, using Eastman Kodak 127-04 emulsion. Meanwhile the UK Schmidt is well advanced with the deep blue survey on Eastman Kodak IIIaJ emulsion, and has taken very nearly half of the required plates. There are 606 fields in each survey, covering the sky from -17° declination to the south pole.

The ESO-SRC Atlas, consisting of film copies of blue and red copies of 606 fields (in all 1212 films), is being made at the ESO Sky Atlas Laboratory in Geneva. The first shipment, of about 50 SRC IIIaJ photographs, is now ready for despatch. Some examples can be seen at the Royal Observatory Edinburgh display in the Science Library.

The price for the 1212 films is now (1976) Swiss francs 16'480.-. Orders may be placed with : ESO Sky Atlas Laboratory, c/o CERN, CH-1211 Geneva 23, Switzerland, to which further enquiries may also be addressed.

Comments

By Plaut in answer to Gehrels question concerning field corrections to photographic photometry on plates taken with the Palomar Schmidt.

On the average the field correction of the Palomar Schmidt can be neglected. It's varying from one plate to the other. Iris photometry on Schmidt plates is only possible at bad seeing. High accuracy is not possible at all : mean error of a single measurement = ± $0^m\!.15$ to $0^m\!.20$ (external m.e.).

By M.F. McCarthy

It is most interesting to have these remarks on field errors by Dr. Plaut. Recently Dr. Kunz and colleagues at Berkely have been investigating magnitude and colour errors and the relation between photoelectric on photographic systems. Here at Grenoble Prof. Luyten, in reply to a question concerning distance errors of positions on plates taken with the Palomar Schmidt, indicated that because of the differential methods employed in the automatic engine used by him and because of the numerous standard stars employed as reference points over the whole field, distance errors are negligible. Perhaps by careful measures with the PDS or Joyse-Lobel equipment sufficient photometric standards could be established over the entire Schmidt plate and differential photometry be carried out by reference to these. One would still, in low latitude fields in the Milky Way, have problems of crowding and from background nebulosity especially for faint objects. Accurate Schmidt photometry has been a problem since the time of Schmidt magnificent invention.

8 - Ultraviolet photometric systems

By E. Peytremann

Several replies have been received in response to a questionary on photometric systems in the ultraviolet. The characteristics of each system are summarised hereafter, together with one reference to a published article if applicable.

Wavelength units are in nanometers : 1 nm = 10 Å.

1) Wisconsin Experiment Package : Satellite OAO - 2 (NASA)

1a) Spectrometry. Scans from 360 to 185 nm (width = 2.2 nm) and from 185 to 116 nm (width = 1.2 nm), steps of 1.0 nm. Calibration is absolute (pre-flight) and the relative accuracy is about ± 0^m06. Ref. : Code et al., 1970, ApJ, 161, 377. Data have been published by Code and Meade, 1976, Wisconsin Astrophysics No 30, "Atlas of UV Stellar Spectra".

1b) Photometry. Twelve bands with following wavelengths and widths in parenthesis : 425.2 nm (86), 331.7 (52), 298.5 (41), 294.5 (43), 246.2 (38), 238.6 (36), 203.5 (49), 191.3 (26), 167.9 (26), 155.4 (24), 143.0 (24), 133.3 (20). Relative accuracy is about 0^m04. Absolute accuracy is 35 % from 110 to 130 nm, 21 % from 130 to 180 nm, 8.5 % from 180 to 330 nm, 4 % from 330 to 810 nm. A catalogue of about 500 stars is in preparation. Data also available on magnetic tape or microfilm from National Space Science Data Center (NASA, Goddard Space Flight Center, Greenbelt, Md., USA).

2) Celescope Satellite OAO - 2 (NASA)
From bands with following wavelengths and widths : U1, 258.2 (55.0) ; U2, 230.8 (90.0) ; U3,162.1 (32.5) ; U4, 153.7 (62.5 nm.
In-flight calibration : about 0^m2 for U2 and 0^m3 for U3. U1 and U4 are unreliable. Data have been published for about 5000 stars by Davis et al., 1973, "Celescope Catalogue of Ultraviolet Stellar Observations", Smithsonian Press, Washington, D.C., USA). Data are available on tape from National Space Science Data Center, for US residents, and from World Data Center A for Rockets and Satellites, Code 601, Goddard Space Flight Center (Greenbelt, Md., USA) for non-US residents.

3) Ultraviolet Sky Survey Telescope
Satellite : ESRO-TD1 UK/Belgium Experiment : S2/68
Spectrophotometry. 3 channels from 137.2 to 174.8 nm, 177.1 to 214.7 nm, and 216.9 to 254.5 nm. About 22 steps/channel and resolution of about 3.6 nm. In addition there is one wide-band channel at 274 nm and width about 32 nm. Absolute accuracy is about 20 % and relative accuracy is about 10 %. For calibration, the reference is : Humphries et al., 1976, Astron. Astrophys., 49, 389. A catalogue of about 1400 stars is to be published by European Space Agency : "The UV Bright Star Spectrophotometry Catalogue". Further information about available data (magnetic tape, etc.) should be requested from Prof. A. Monfils (Institut d'Astrophysique, Liège, Belgique).

4) Ultraviolet experiment, Astronomical Netherlands Satellite (ANS)
Six bands with following wavelengths and widths : 154.9 (14.9), 154.5 (5.0), 179.9 (4.9), 220.0 (20.0), 249.3 (15.0), 329.4 (10.1) nm. Absolute and relative accuracy are respectively 20 % and 10 %. Reference : Van Duinen et al., 1975, Astron. Astrophys., 39, 159. A catalogue with data for about 6000 stars will be published. Data can be made available on special request. Requests should be addressed to Dr. R.J. van Duinen, Laboratory for Space Research, P.O. 800, Groningen, Netherlands.

5) Ultraviolet extended sources : French satellite D2B
There are three experiments of the Laboratoire d'Astronomie Spatiale, Marseille, France. Mainly devoted to extended sources photometry (Milky Way, zodiacal light), it can also observe bright stars.

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5.1) Anti-Sun instrument for ecliptic plane objects (within 4°) and with 4 bands : 310 nm (30), 255.0 (30), 160.0 (30), 85.0 (10).

5.2) Whole sky survey in the following 4 bands : 310 (30), 220 (30), 160 (30) and 121.6 (30).

5.3) UBV photometry of stars near ecliptic plane ($m_V \leq 8$) : 380 (200), 400 (150), 430 (100).

Absolute calibration should allow accuracy better than 20 %. Ref. : Presentation of zodiacal light instrument aboard the D2B astronomical satellite : IAU Colloquium No 31, 1975, Heidelberg, W. Germany. Requests for additional information should be addressed to : Dr. P. Cruvellier, Laboratoire d'Astronomie Spatiale, Traverse du Siphon, 13012 Marseille, France.

6) Ultraviolet Photometry from Balloons (experiments from Observatoire de Genève, Switzerland.

6.1) 6 channels at : 213 (12.5), 227 (12.5), 248 (12.5, 262 (14), 286 (15), and 304 (14) nm. 12 stars have been observed. Average altitude : 38 km.

6.2) 8 channels at : 205.2 (3.8), 218.4 (3.5), 271.8 (5.5), 295.4 (5.6), 307.4 (6.8), 336.6 (4.6), 402 (36), and 520 (40) nm. 14 stars members of Pleiades cluster have been observed so far. Average altitude : 40 km.

Results published so far concern only the analysis of absorption by Ozone. Ref. : Rigaud et al., 1975, Ann. de Géophysique, 31, 455. Further information can be obtained from Prof. M. Golay, Observatoire de Genève, CH-1290 Sauverny, Switzerland.

COMMISSION 26: DOUBLE STARS (ETOILES DOUBLES)

Report of Meetings, 25 and 27 August 1976

PRESIDENT: S. L. Lippincott SECRETARY: O. G. Franz

First Session

President Lippincott called for a moment of silence to honor the memory of Commission members and double star researchers lost by death since the 1973 meeting: G. van Biesbroeck, W. H. van den Bos, J. Hopmann, H. M. Jeffers, R. Jonckheere, G. F. G. Knipe, C. P. Olivier, and F. Zagar.

I. ADMINISTRATIVE MATTERS

At the recommendation of the President, the Commission endorsed as new members: H. Abt, E. H. Geyer, J. L. Hershey, K. D. Rakos, and A. Poveda. Deleted from membership were S. S. Kumar, R. E. Nather, and U. Güntzel-Lingner, because of inactivity in double star research. The Commission endorsed A. Batten, M. Fracastoro, R. S. Harrington, S. L. Lippincott, and C. E. Worley for the Organizing Committee, P. Muller for President, and O. G. Franz for Vice President.

The President invited discussion on a definition of the Commission's scientific objectives: "The Commission on Double Stars has for its objectives the organization and promotion of all research pertaining to stellar systems for which two or more components are astrometrically observable."

After Worley, Dunham, and Batten commented on the difficulty of finding a precise definition and on the need to exercise judgment on what is of interest and importance, the Commission adopted the proposed statement of scientific objectives.

Concerning proposed working rules, Worley questioned the outgoing president automatically becoming a member of the Organizing Committee. Batten and Fredrick defended such a procedure as common practice to provide continuity.

The Commission then adopted, by a vote of 7:0 with three abstentions, the following three of six articles of the "Proposed internal rules and regulations for the appointment of officers and Organizing Committee members of Commission 26, IAU":

> The Board (President and Vice President and O.C.) comprises one member per six or fraction thereof members of the commission (ex.: 7 for 38). The appointment of a member normally covers two General Assemblies (two terms) of the Union. The Board is changed at each General Assembly according to the following rules:
>
> 1) The outgoing president shall be an ex-officio member of the O.C. in excess of the number defined above, for one term.
>
> 2) The vice president normally becomes president.
>
> 3) Among those to be replaced are: a) those who have completed the second term; b) those who wish to retire after one term; c) those who leave the commission or die during a term.

No action was taken on articles 4-6 dealing specifically with the designation

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of Organizing Committee members and Candidates for vice president, pending further review by and proposals from Commission members.

II. INDEX CATALOG AND CATALOG OF OBSERVATIONS

Worley reviewed the status of the catalogs. At present the Index Catalog contains 70,295 entries, an increase of 6,058 since 1963; this gain does not yet include new lists by Couteau and Luyten. The Observation Catalog, at 1976.5, contained 301,995 entries, a growth of 93,123 since the catalog's transfer to the U. S. Naval Observatory. Among these new entries are 46,085 pre-1927 northern-hemisphere observations not previously contained in the catalog. Their inclusion is a project undertaken: 1. to make these measures available to astronomers not having access to the original publications; 2. to preserve the data, since few copies of the original publications exist and some are deteriorating, posing the danger that valuable data may be lost. An estimated 30,000 old observations remain to be processed, for an ultimate total of 76,000.

The use of the catalogs is expanding rapidly, from about 15 to a current 45 to 50 requests per year.

Access to documentation is a problem. When data were transmitted from E. Doolittle to the Lick Observatory, the original cards with handwritten entries were passed along. However, when responsibility for the catalogs was transferred to the U. S. Naval Observatory, these documents remained at the Lick Observatory and are not readily available for cross-checking, verifications, identification checks, elimination of duplications, etc.

Addressing this problem, the following resolution was unanimously adopted: "Commission 26 on Double Stars, recognizing the value and importance of documental material now located at the Lick Observatory and pertaining to the Double Star Index and Observation Catalogs, urges that these documents be provided or made readily accessible, in originals or copies, to U. S. Naval Observatory personnel responsible for the maintenance of these Catalogs."

III. TERMINOLOGY CONCERNING DYNAMICAL PARALLAXES

Dommanget reviewed the history of dynamical parallaxes. He proposed that the terms "orbital" and "non-orbital" dynamical parallaxes be used to distinguish a parallax based on known orbital elements from one computed on the basis of observed motion insufficient to define an orbit, to alert the user to the difference in accuracy of these two types of dynamical parallaxes (Dommanget, J. 1976, Ciel et Terre **92**, No. 2).

Worley and Franz questioned the need to consider dynamical parallaxes, since they provide no independent information. At best they can serve to resolve ambiguities and to provide a check on the consistency of dynamical and physical characteristics of binaries, e.g., whether a given pair is or cannot be composed of main-sequence stars.

IV. LUNAR OCCULTATION OBSERVATIONS

D. S. Evans discussed the detection and measurement of close double stars from observation of the occultation of stars by the moon, warning particularly against over-interpretation of the recorded diffraction patterns. Illustrating the capabilities of the technique, he described observations with four tesescopes at the University of Texas of the occultation of β Sco on 8 July 1976, which led to the positive identification of five component stars. Combination of these results with observations at other sites could yield true angular separations and position angles. While occultations thus provide distinct possibilities for the discovery and study of close pairs, one should not expect results on specific (spectroscopic) binaries. Dunham remarked that the July 1976 and September 1975 occultations of β Sco were indeed observed at other sites. He also called

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attention to his list of double stars in the zodiacal zone, particularly of new discoveries. Dunham and G. Taylor hope to expand their predictions of the occultations of stars by minor planets; observations of such events should increase the accuracy and number of stellar-diameter determinations, yield diameters of asteroids, and lead to the discovery of more double stars.

V. CIRCULAIRE D'INFORMATION - P. MULLER

La Circulaire d'Information a pour origine une idée venue en même temps et indépendamment au Prof. W. Rabe et à moi-même; on trouvera dans la première le texte intégral de la proposition de W. Rabe dont l'essentiel concordait avec mon projet. La Circulaire a été diffusée à partir de 1954, et la Commission a pris à Dublin (1955) une résolution qui approuvait la formule adoptée et me confiait la charge de l'éditer jusqu'à nouvel ordre.

La liste d'envoi comprend d'abord les membres de la Commission; en outre, j'ai retenu un certain nombre d'astronomes non membres et d'établissements divers en raison de leur intérêt pour les étoiles doubles. Quelques omissions ont pu persister un certain temps avant d'être réparées et je prie les intéressés de m'excuser ici pour ces anomalies. Le Secrétariat de l'U.A.I. recevait 11 exemplaires, mais se contentera de 2 à partir de cette année. Au cours des années, j'ai reçu de nombreuses demandes soit d'astronomes, soit d'institutions qui désiraient ce service et je les ai ajoutés sur ma liste, sauf dans quelques cas où le demandeur se trompait évidemment sur la nature de la publication. La liste d'envoi compte actuellement (juillet 1976), 75 adresses, et la Circulaire paraît à dates fixes (mars, juillet et novembre), avec parfois un numéro bis pour des compléments.

Je tiens à souligner, comme je l'ai fait déjà en 1970 à Brighton, que la Circulaire est à mes yeux en document provisoire, où l'on trouve des données fournies avant publication, avec toutes les possibilités d'erreurs matérielles (liées surtout à la rapidité de la composition) et même de corrections d'auteur ultérieures que cela comporte; il convient donc de s'imposer la vérification de ces données lors de leur publication définitive qui doit toujours suivre. Je précise par ailleurs que la Circulaire a toujours été composée et diffusée par les soins de mon personnel et des services généraux de mon établissement.

A la Circulaire de mars dernier était joint un bref questionnaire destiné à recueillir les suggestions des usagers et à contrôler les adresses. Je remercie tous ceux qui ont répondu soit par cette voie, soit personnellement comme je le leur proposais également. Dans l'ensemble, la formule et le contenu paraissent approuvés, et le désir général est de voir la Circulaire continuer telle qu'elle est. Une seule suggestion précise m'a été faite (Belgrade), celle de publier des références bibliographiques notamment de séries d'observations. Il me semble, après réflexion, que dans l'esprit de la Circulaire la référence normale et certainement utile serait l'annonce de publications prochaines. J'invite donc les observateurs à bien vouloir, s'ils l'acceptent, m'informer au moment de la remise de leur manuscript ou de la correction des épreuves, avec les indications utiles: instrument, époque et nombre des mesures, journal ou revue et date probable de la parution.

En bref, comme la Circulaire est d'abord l'oeuvre de ceux qui m'en fournissent la matière, bien plus que la mienne, je les remercie tous pour en avoir assuré le succès et j'espère pouvoir compter encore sur eux dans l'avenir.

Second Session

VI. THE STATE OF DOUBLE STAR ASTRONOMY IN SOUTH AFRICA - J. HERS

At the Lamont-Hussey Observatory, all double star observations ceased with the departure of F. Holden. The 27-inch refractor was later dismantled, and the objective shipped back to the U.S.A. Today only the dome remains.

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The Republic Observatory's 26½-inch refractor remained in intermittent use for planetary photography until 1973; but in the absence of suitable observers, the double star program was never resumed and no observations have been made since 1971. In official quarters a very low priority was assigned to double stars, and no definite decision appears to have been taken on the ultimate future of the telescope. However, the likelihood of the telescope's being moved to another site appears very small. To house the 10-meter tube, a very large, expensive dome would be needed, and funds would be far better employed keeping the instrument in operation at the present site rather than to develop a new site. While it is true that the present site is now entirely surrounded by the city, this has relatively little effect on an instrument of such long focal length. The recent promulgation of smokeless zones has actually tended to improve conditions. As far as seeing associated with atmospheric turbulence is concerned, comparisons of recent observing reports with those of the 1920's show no noticeable change. An excellent instrument remains therefore available, waiting to be used. It was recently suggested that local amateurs might use it to observe visual double stars, but no one has yet come forward, and it seems unlikely that anything will happen. On the other hand, it is probable that facilities would not be refused to observers from elsewhere, as long as this did not involve extra expenditure. It would be of the greatest value to southern double star astronomy if the 26½-inch refractor could be put back into regular use as soon as possible.

VII. BRIEF SCIENTIFIC COMMUNICATIONS

a) Rakos reviewed the program of area scanner observations of visual double stars on the UBV and the Strömgren systems now in progress in Vienna. Several thousand observations of the combined light, magnitude differences, and relative positions of the components of about 250 pairs with separations of less than 1 arcsec to about 7 arcsec have been obtained in Vienna, Chile and Hawaii. Final data reduction is being completed.

b) Strand reported on new mass determinations for white dwarfs. Analysis of the orbital motion of Stein 2051 = G175-34 shows the red-dwarf component to have a 20-year perturbation. Of the two possible orbital solutions, the less plausible one indicates the presence of a "dark" companion of 0.02 solar masses. The computed masses of the visible red-dwarf and white dwarf components would be 0.22 and 0.48 solar masses, respectively. The second solution assumes the red-dwarf to be a close binary of $\rho \sim 0.7$ arcsec and $\Delta m = 0.5$ mag and yields 0.18 and 0.16 solar masses for the red-dwarf and its close companion, respectively. The mass of the white-dwarf component becomes 0.68 solar masses.

Also studied was the system G107-69, 70, whose fainter component was found to be a close binary. Some photographs obtained at the U. S. Naval Observatory showed the binary image sufficiently elongated to permit measures of the relative positions of its components, yielding a provisional orbit of $P = 16.6$ years and $a = 0.67$ arcsec. Photometry and spectrophotometry indicate both components to be nearly identical, late degenerate stars of 0.9 solar masses each, based on $\pi = 0.085$ arcsec. These investigations raised from three to six the number of known white-dwarf masses.

c) Franz reported on his discovery of the variability of the carbon-star component of ADS 14338. The observed, seemingly irregular brightness changes of at least 1.5 mag in B and V can be represented by a combination of two regular variations with periods of 87 and 364 days, suggesting that the carbon star is probably an unresolved binary with two variable components.

COMMISSION 27: VARIABLE STARS (ETOILES VARIABLES)

REPORT OF MEETINGS, 27, 28, 31 August 1976

PRESIDENT: M.W. Feast SECRETARY: L.N. Mavridis

27 August 1976

SCIENTIFIC MEETING

Commission 27 was responsible for part of the organization of the Joint Meeting (Commissions 25, 27, 29, 35, 36 and 42) on "Observational Evidence of the Heterogeneity of the Stellar Surface" (half-day). Speakers were: D.J. Mullan, M. Hack, D.S. Evans, D.M. Popper and J.W. Harvey.

28 August 1976

SCIENTIFIC MEETING

This meeting was devoted to the subject "Infrared and Radio Observations of Variable Stars". Speakers were: C.C. Wu, M.W. Feast, T. Gehrels (who read a paper by G.V. Coyne), A. Winnberg and J. Morris.

ADMINISTRATIVE MEETING

The composition of the new Organizing Committee for submission to the IAU Executive Committee was decided by an election. Also a list of new members of the Commission was approved.

Following the announcement by the President that Professor P.F. Chugainov had resigned as Chairman of the Working Group on Flare Stars the Commission appointed Professor L.N. Mavridis as new Chairman of this Working Group.

There was some discussion of a circular letter from the Moscow Variable Star Bureau asking for suggestions for the preparation of the Fourth Edition of the *General Catalogue of Variable Stars*. A motion for the continuation of the annual subvension from the IAU to the Moscow Variable Star Bureau for their work on the *General Catalogue of Variable Stars* was proposed by Professor R.E. Gershberg, seconded and carried unanimously.

Professor G. Herbig proposed that the editors of Astronomy and Astrophysics Abstracts be asked to cross reference individual variable stars by name (as in the old Jahresbericht). This motion was seconded and carried unanimously.

Dr B.C. Marsden gave a brief account of the problems connected with the inclusion of announcements concerning variable stars in the *Telegrams* and the *Circulars* of the Central Bureau for Astronomical Telegrams. It was decided to encourage people interested in U Gem stars to contact Dr Marsden so that information on these stars could be forwarded to them without delay.

The President informed the Commission about the present state of the organization of the IAU Colloquium No. 72 "The Interaction of Variable Stars with their Environment" to be held in Bamberg (FRG) in September 1977. The possibility that an IAU colloquium on "Duplicity and its Consequences amongst Variable Stars" be held in New Zealand was discussed. It was noted that the IAU Executive proposed instead that this topic be placed on the programme of the IAU regional meeting planned for New Zealand.

Following a suggestion by Professor L. Plaut the Commissions decided to urge the co-ordinators of co-operative variable star observations to ensure that the corresponding results are published.

31 August 1976

SCIENTIFIC MEETING

This meeting was devoted to the subject "Pulsation of Giant Stars in the Instability Strips (Theory and Observations)". Speakers were: P. Demarque, B. Madore, A.N. Cox, R. Stobie, J.R. Lesh, D.S. Evans, W. Dziembowski, N. Nikolov.

COMMISSION 28: GALAXIES (GALAXIES)

Report of Meetings, 25, 26, 30 and 31 August 1976

PRESIDENT: E. B. Holmberg SECRETARY: B. E. Westerlund

There were four sessions, of which the first dealt mainly with business matters, the second was a joint meeting with Commission 34 on Interstellar Matter in External Galaxies, the third was devoted to the Structure and Evolution of the Magellanic Clouds, and the fourth was an all-day joint discussion with Commissions 47 and 48 on Clusters of Galaxies, Cosmology and Intergalactic Matter.

25 August 1976

BUSINESS MEETING

Members stood in silence for one minute in memoriam of R. Minkowski and F. Zwicky.

I. NEW OFFICERS AND MEMBERS

The Commission unanimously approved the election of the new President, B. E. Markarian, and Vice-President, B. E. Westerlund. The President proposed and the Commission unanimously approved, the list of names proposed for the new Organizing Committee. It was agreed that the Secretary should be selected by the new President.

A large number of proposals for new members of the Commission had been received. The Organizing Committee had screened the list, and presented the names of those they regarded qualified to the Commission for consideration. As a general rule was accepted that only those who have been members of the IAU for three years where eligible as Commission members. It was also recommended that the Organizing Committee consider the problem of non-active members. Following the discussion the Commission members approved unanimously the list of new members presented.

II. COMMISSION RULES

It was decided that no further rules are needed at present. A discussion followed concerning the form of meetings during IAU General Assemblies and the future form of Commission reports. It is expected that the Executive Committee of the IAU will present new instructions regarding both items.

III. PROPOSED RESOLUTION

Following a proposal by Dr. G. de Vaucouleurs the Commission decided to recommend to the Union "that in the standard correction of extragalactic redshifts for solar motion with respect to the Local Group $\Delta V = 300 \cos A$, the definition of the solar apex be changed from $l^{I} = 57^{o}$, $b^{I} = 0^{o}$ to $l = 90^{o}$, $b = 0^{o}$, but that no change be made in the conventional value of the solar velocity $V_{\odot} = 300$ km s^{-1}".

IV. WORKING GROUPS

The Commission discussed the need of a working group for extragalactic studies from space and decided that a group should be formed.

V. CATALOGUES OF GALAXIES

The President read a request from Dr. Vorontsov-Velyaminov in which he asks that the numbers in his Morphological Catalogue be used.

VI. SCIENTIFIC PAPERS

The following short papers were presented during a brief session following

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the business meeting:

S. van den Bergh: M 104

W. Baum and R. Florentin Nielsen: Old and Young Photons.

R. S. Dixon: Galaxy Catalogues on Magnetic Tape.

L. Bottinelli, L. Gouguenheim: HI in Markarian Galaxies.

J. Stock and H. Alvarez: The Status of the Venezuelan Schmidt Camera.

A. de Vaucouleurs, G. de Vaucouleurs and H. Corwin: The Second Reference Catalogue of Bright Galaxies.

G. Reaves: Dwarf Galaxies in the Virgo Cluster.

W. G. Tifft: Mean Redshifts in the Perseus Cluster.

J. P. Vigier: The Influence of the Local Supergalactic Cluster on Radial Velocities.

B. M. Lewis: Orbits of satellite galaxies.

26 August 1976

SCIENTIFIC MEETING

A report on this meeting will be found under Commission 34. The following papers were presented:

G. Courtés: HII Studies of Local Group Galaxies.

B. L. Webster: Interstellar Abundances in External Galaxies.

M. Peimbert: The Helium Problem.

R. Sancisi: Galactic Warps: Observations.

A. Toomre: Interpretation.

H. van Woerden: Gas Content of Early-Type Galaxies.

30 August 1976

SCIENTIFIC MEETING

In the session on The Structure and Evolution of the Magellanic Clouds the following papers were presented:

G. de Vaucouleurs: Structure, Composition and Dynamics of the Magellanic Clouds and other Late-type Barred Spirals.

A. Ardeberg: The Evolution of the Large Magellanic Cloud.

Th. Schmidt-Kaler: The Spiral Structure, the Dynamics and the Activity Centre of the Large Magellanic Cloud.

M. T. Brück: The Structure of the Small Magellanic Cloud.

D. S. Mathewson: The Magellanic System.

R. J. Dufour (read by B. E. Westerlund): The Structure and Chemical Composition of Gaseous Nebulae in the Magellanic Clouds.

B. M. Lasker: Supernova Remnants and H II Regions in the Magellanic Clouds.

ABSTRACTS OF THE PAPERS:

G. de Vaucouleurs: A review was given of the progress in our understanding of the Structure, Composition and Dynamics of the Magellanic Clouds and other late-type barred spirals during the past 25 years.

Reference was made to review papers by Buscombe, Gascoigne and de Vaucouleurs (Australian J. of Science Suppl. 1954), by de Vaucouleurs and Freeman (Vistas in Astronomy, vol. 14, 1972), to several IAU Symposia and to the bibliography published in 1972 by the Carter Observatory, N. Z.

Ardeberg: The clusters in the LMC deserve special interest as they provide favourable means for improvements of evolutionary tracks of massive stars. The well-known distance, low reddening and ample number of young clusters are attractive. Large-scale studies of LMC clusters were made already by Westerlund (1961). Recently, substantial amounts of photographic photometry were made by Robertson (1974) and by Flower and Hodge (1975). Fundamental discussions were drawn up on core-helium-burning stages of evolution.

Whereas the colour distribution of field and cluster stars may be similar, such a similarity can hardly be expected for colour-magnitude diagrams. Thus, it should be a major concern to discriminate against contamination of cluster colour-magnitude diagrams by field stars.

For Robertson's data restriction to stars in his central fields markedly changes the population of the core-helium-burning region. Noticeable are reductions in the number of red giants as well as their luminosity range and in the number of stars above the main sequence. It is suggested that restriction would increase the power of these excellent data. Generally, the only practical remedies seem to be restriction of cluster radii observed and/or observations of wide areas around each cluster for reduction of the effects of field stars.

The picture given by restricted Robertson data is good evidence for the overall validity for LMC stars of accepted evolutionary tracks for high-mass stars. Reference may be made to Iben (1967) and to Stothers and Chin (1976) and to Lamb, Iben and Howard (1976).

The first large-scale study of LMC structure was that of de Vaucouleurs and Freeman (1972). Through data compilation from direct photography, surface photometry and star counts they out-lined what they named "an extended spiral structure". Spectacular is a γ-shaped arm structure extending from the Bar. The methods for structure delineation chosen by de Vaucouleurs and Freeman are maybe not the very sharpest. A wide variety of populations are mixed in a way hard to predict and disentangle.

Few objects can challenge the super-giant stars in terms of delineation power for young features. The surveys of Sanduleak (1970) and Fehrenbach and Duflot (1970, 1973) gave remarkable possibilities for large-scale studies of such stars. Sanduleak selected nearly 1300 LMC members from small-dispersion objective-prism plates. For evolutionary studies a severe restriction is the spectral-type bias caused by the small dispersion. Fehrenbach and Duflot used radial velocity as a membership criterion and thereby avoided spectral-type bias. Nearly 600 LMC members were found.

Using mainly the catalogues of Fehrenbach and Duflot an extensive observational programme was carried out at ESO (Ardeberg et al., 1972) including MK classification, radial-velocity determinations and photoelectric UBV photometry. This way more than 400 stars could be classified as definite members of the LMC.

In an attempt to delineate the young structure of the LMC Ardeberg (1976) made use of primarily these ESO data and secondly of LMC members given by Sanduleak. Whereas the ESO data should be entitled to the absolute preference, the richness of the Sanduleak data make it an excellent back-up material. The picture emanating is one of well-defined concentrations of super-giant stars with surface densities considerably higher than that of the general field. The few super-giant stars seen within the Bar area are probably to a high degree superposed. The Bar is not a place of significant, recent star formation. The contrary is true for the 30 Dor complex, marked by heavy star formation, which is also true for three other major concentrations of super-giant stars.

The structure defined by super-giant stars is in excellent agreement with that from far-ultraviolet photographs (Watts, 1972). It is also in good agreement with that defined by associations, HII regions and large HI complexes. Thus, the extreme population I seems to belong to the concentrations mentioned. These concentrations do not present any convincing evidence of spiral structure.

Comparison with structural features given by de Vaucouleurs and Freeman shows that except for the 30 Dor complex only the γ wings are conformed. However, from the picture given by well-defined population I objects it seems hard to see any convincing connection between these wings and the Bar, especially for the Southwest feature.

Using the ESO data plus his own photometry of Sanduleak stars Isserstedt (1975) examined the structure of the LMC. The resulting distribution is rather similar to the distribution of super-giant stars referred to above. However, Isserstedt concludes that super-giant stars are distributed in longish filaments with widths increasing with increasing intrinsic colour. Further, he states that "Eine klar gegliederte zweiarmige Spirale ist allerdings nicht erkennbar". Thus, Isserstedt finds no indication of a two-armed spiral structure.

Schmidt-Kaler and Isserstedt reanalyzed the material just used by Isserstedt plus some other objects. The main tracers used are supergiant stars and HII regions. However, only super-giant stars with $(U-B) \leq -0^{m}.6$ are taken into account. Schmidt-Kaler and Isserstedt find a clear spiral pattern with two main arms emanating from the 30 Dor complex and completely unrelated to the Bar. It may be noted that stars with $(U-B)_0 \leq -0^{m}.60$ formed one of the groups earlier studied by Isserstedt.

With the strongly mass-dependent evolution of super-giant stars the colour is a doubtful age parameter. The colour limit adopted by Schmidt-Kaler and Isserstedt may not be extremely clear-cut. Accepting the data selected by Schmidt-Kaler and Isserstedt one finds that they connect into spiral pattern features which may otherwise be regarded as individual concentrations of objects from the extreme population I. It is emphasized that the two major gaps in the outer of the two main "arms" are situated in its inner part and at the prolongation of the Bar, whereas the inner "arm" passes right through the Bar or in front of it. As the density-wave theory is incompatible with the structure proposed, Schmidt-Kaler and Isserstedt suggest an ejection theory.

Martin et al.(1976) deal with the structure of the LMC defined by super-giant stars. Using objective prism plates of fairly high dispersion they classify all stars mentioned above and previously not classified at comparable dispersion. A structure of major concentrations is found, which is very similar to that discussed above. Martin et al. find that their data fit the γ wings of de Vaucouleurs and Freeman, whereas the other concentrations do not correspond very well to the structure drawn by these authors. Martin et al. also state that the spiral structure suggested by Schmidt-Kaler and Isserstedt "seems to be out of question".

A modest number of papers have been specifically concerned with the large-scale evolution of the LMC. Payne-Gaposhkin used Cepheids of ages up to 10^8 years. She suggested that during the past 10^8 years star formation slowly advanced along the direction of the Bar. There may well be such a tendency. For the time being there are no other reliable observational data adequately covering this time interval.

Hodge (1973) used young clusters for a study of the recent evolutionary history of the LMC. He covered a time interval of 14×10^6 years and concluded that clusters form in space-time cells with dimensions 1 kpc and 10^6 years, well isolated in space and time. Identification of turn-off points with the brightest stars and (especially) assignment of single cluster ages are procedures which may not be fully compatible with Hodge's estimate of the uncertainty in a single cluster age, being 10^6 years. This in turn throws some doubt on the mentioned space-time cells.

From the ESO data mentioned earlier the large-scale star formation in the LMC was studied over the past 2×10^7 years (Ardeberg, 1976). From the positions in the $\log L/L_{\odot}$; $\log T_e$ diagram and corresponding isochrones ages of super-giant stars were determined. The resulting intrinsic "birth function" shows that during the time interval studied star formation was essentially a one-event feature, occurring around 8×10^6 years ago. Local deviations from the over-all birth function seem to be of low significance. If for the total area studied by Hodge, cluster birth rates are derived, a birth function is found which is in good agreement with that defined by super-giant stars. It may be concluded that this evolutionary picture is hardly compatible with spiral-structure type generation of stars. It is, however, in good agreement with Biermann's (1976) models of galaxy evolution.

Schmidt-Kaler: If the structure of the LMC is investigated by means of the best spiral tracers a clear spiral pattern emerges (embedded in an underlying E5 galaxy) corresponding to an Sc(-c$^+$) III-IVp galaxy, the peculiarity being the deviation from the usual diametral symmetry of the two main spiral arms. This was demonstrated by an overlay of the distributions of: HII regions, blue supergiants, dark clouds and interstellar reddenings, OB-associations, supernova remnants and WR-stars etc. Ardeberg's supergiants with ages up to 10^7 yrs are lined up along exactly the same spiral arms, the older supergiants show (as in our Galaxy) a broader distribution smearing out the sharp spiral features. The HII-regions with diameters of 6 pc or more are the best spiral tracers (just as the giant HII regions in our Galaxy) while the smaller ones are scattered due to age and selection effects. Near 30 Doradus, the centre of the spiral features, dark clouds delineate the spiral structure best (just as in M31).

The structure is also well visible in Fig. 6 of Martin et al. (Astron. Astrophys. 51, 1976, 31). It appears that de Vaucouleurs' γ-structure is based only on B7-A9 supergiants and bright cepheids, but it should be stressed that in our Galaxy spiral structure is well outlined only by the youngest objects of the (extreme) population I.

The spiral structure extends over 6.1 kpc almost identical to that of the comparable ScII-III galaxy M33.

The history of past star formation activity can be studied by means of the width and distance from the axis of the spiral arms which correlate well to each other and to the stellar age. Thus, the average age of WR and SNR is estimated at 3 and $5.5 \cdot 10^6$ yrs, resp. Two bursts of star formation can be recognized: the last one culminated $8 \cdot 10^6$ yrs ago, and centered on 30 Dor and the actual spiral structure; an earlier one culminated $60 \cdot 10^6$ yrs ago and centered on the bar.

The spiral features and the magnetic fields are focussed on the unique super-giant HII complex 30 Doradus. It plays the same exceptional role among all HII regions of the LMC as SgrA among those of our Galaxy, and shows the essential properties of a galactic nucleus with the semistellar object HD 38268 at the very centre. Evidence for its activity is given by the peculiar, nearly radial filaments of the nebula, its expansion velocity of about 50 km s^{-1} and the corresponding mass loss of 0.05 $M_{\odot}$ /yr, and the variability of HD 38268 (O + WN, with the extreme luminosity $M_v = -11$) on short time scales.

Discussions of the kinematics of the LMC yields a geometric line of nodes at p = 168° with i = 33°, and a kinematic line of nodes at p = 188°, the difference being due to a transversal motion of 150 km s^{-1} parallel to the Magellanic stream implying bound motion of the LMC around the Galaxy.

Detailed papers appeared in: HII Regions and Related Topics (ed. T. L. Wilson and D. Downes), Springer Lecture Notes 1975, p. 484; Astrophys. Space Sci. 41, 1976, pp 139 and 357; Third Europ. Meeting IAU (Tbilissi 1976), in press; Astron. Astrophys., in press.

Mrs Brück: Descriptions of the geometrical structure of the SMC by de Vaucouleurs and Freeman (1972) and of the stellar content of its various features by Westerlund (1972) have already been the subjects of review articles.

In this paper, the structure of the Cloud and its evolution are studied by considering the distribution of objects of various ages. The youngest objects, the HII regions (1 to 2 x 10^6 years) clearly outline the wing and bar (Davies, Elliott and Meaburn 1975). Somewhat older B stars (Sanduleak 1975) also occupy these regions and correlate with HI contours.

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Star clusters (Hodge and Wright 1974; Brück 1975 and 1976) when divided by colour and age show the youngest them (10^6 to 10^7 years) in the bar and wing, small open clusters (10^7 to 10^8 years) throughout the disk while red globular clusters (estimated age 10^9 years) congregate in the SW region of the Cloud. Plots of Cepheid distributions by age (Payne-Gaposchkin and Gaposchkin 1966) show a similar tendency for younger objects (4×10^7 years) to favour the bar and wing whose outlines become blurred as one reaches older objects (4×10^8 years). This may indicate the date of possible close encounter (3 to 5×10^8 years ago) of the Magellanic Clouds with the Galaxy, though Mathewson and Schwarz (1976) have recently sounded a note of caution as regards the encounter hypothesis. By contrast the planetary nebulae which are classified as older disk objects in our Galaxy, appear to line up along the bar of the SMC (Westerlund 1968).

Interstellar matter in the SMC derived from galaxy counts (Hodge 1974, Mac Gillivray 1975) and a dark nebulae survey (Hodge 1974b) show elliptical contours and also individual patches of obscuration in the wing and in what appears to be a counter tide or wing in the diametrically opposite region.

The halo of the SMC has been traced on UK 1.2 m Schmidt telescope plates reaching B magnitude $21^m.5$ in fields to the east of the main body of the Cloud. Using the COSMOS measuring machine in its star-counting mode, equidensity contours show that the halo extends in an apparently circular fashion to a distance of $4^\circ.4$ from the centre. This compares with the effective radius of $1^\circ.5$ of the elliptical contours of integrated light and of star clusters. The "Shapley wing" protrudes from the circular halo a further 2°.

Review articles:

de Vaucouleurs, G., and Freeman, K.C., 1972 Vistas in Astronomy, vol. 14, 184.

Westerlund, B.E., 1972 Proceedings of the First European Astronomical Meeting, Vol. 3, 39.

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MacGillivray, H.T., 1975, Mon. Not. Roy. astr. Soc., 170, 241.

Payne-Gaposchkin, C. and Gaposchkin, S., 1966, Smithsonian Contributions to Astrophysics Vol. 9.

Sanduleak, N., 1975, Astron. and Astrophys. 39, 481.

Westerlund, B., 1968, I.A.U. Symposium 34, 23.

Mathewson: The entire Magellanic System has been surveyed by Mathewson, Schwarz, and Murray for neutral hydrogen with the 18-m telescope at the Parkes Observatory, CSIRO, down to a detection limit of 2×10^{19} atoms cm^{-2} and with a velocity resolution of 7 km s^{-1}. In addition HI observations of the Inter-Cloud region have been made with the 64-m telescope at Parkes with a velocity resolution of 4 km s^{-1} using a 15' of arc grid spacing. Detailed maps are presented showing the intensity and velocity structure of the neutral hydrogen over the whole system. For the first time details are known of the transverse velocity component of the Magellanic Clouds from work on the Magellanic Stream (Mathewson 1976; Mathewson and Schwarz 1976). The effects of this transverse motion on the observed radial velocities of the Magellanic System have been removed from the maps.

The results show:

(1) a severe warping of the disk of the LMC

(2) that doubt is cast upon the existence of the three expanding shells of gas in the SMC which Hindman (1967) suggested were responsible for the double

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HI profiles in the SMC. This double velocity structure is probably caused by a warped outer part of the SMC shadowing the central disk in a similar fashion to that found by Rogstad et al. (1976) in M33.

(3) that the Inter-Cloud region is comprised of the outer disk of the LMC, a very extended outer disk of the SMC, and gas in a bridge between the two galaxies. This bridge gas shows the same velocity characteristics as the gas in the SMC, i.e. two components separated by 40 km s^{-1}; although this separation becomes progressively less with distance from the SMC until they merge.

Mathewson and Ford have found a stellar component of the bridge gas from the tip of the Wing at 2^h15^m to 3^h15^m. The radial velocities of these OB stars differ from that of the gas by 40 km s^{-1} which is different to the young stars in the LMC and SMC whose radial velocities are in close agreement with the gas. This indicates that the gas in the bridge is slowing down at the rate of 40 km s^{-1} every few times 10^6 years. The bridge must be a very young feature as already suggested by Westerlund. It also implies that the bridge is not a tidal feature due to the gravitational interaction of the LMC/SMC which would have occurred more than 10^8 years ago.

The bridge has probably just formed from gas in the outer parts of the SMC and this density "wave" in the disk of the SMC has produced stars in a similar manner to that in a more conventional spiral galaxy.

Galaxy counts along the bridge show that the dust to gas ratio is similar to that in the main body of the SMC. There is a displacement of the dust from the main ridgeline of the gas and it is suggested that radiation pressure of the light from the SMC and LMC is driving the dust outwards from the bridge as here it is only loosely coupled to the gas.

References:

Hindman, J.V., 1967, Aust. J. Phys., 20, 147.

Mathewson, D.S., 1976, R.G.O. Bull., No. 182.

Mathewson, D.S., and Schwarz, P. 1976, Mon. Not. Roy. astr. Soc., 176, 47P.

Rogstad, D.H., Wright, M.C.H., and Lockhart, I.A., 1976, Astrophys. J., 204, 703.

Dufour: The Magellanic Clouds constitute the best systems to study the structure and chemical composition of gaseous nebulae in external galaxies. During 1974-1975 accurate spectrophotometric observations of H II regions in both Clouds were published by the Peimberts, Aller and his coworkers, and Dufour, who found that the interstellar gas in the Clouds was metal deficient, particularly in the SMC. In addition, the observations of the Peimberts and Dufour suggest that the He/H ratio is lower in the Clouds also. Chemical abundancies calculated from these observations are summarized below.

Object	log H	log He	log N	log O	log Ne	log S	log Ar
Solar Neighborhood	12.00	11.00	7.64	8.81	8.06	7.4	7.3
LMC	12.00	10.94	6.95	8.49	7.80	7.2	6.6
SMC	12.00	10.91	6.50	8.00	7.30	7.1	6.5

Similar modern observations of planetary nebulae in the Clouds have been published recently by Osmer, Webster, and Dufour and Killen. The new data confirm Feast's discovery that the planetary nebulae in the SMC are generally of low excitation, while those in the LMC cover a range of excitation similar to planetaries in the Galaxy. Abundances derived from these data are rather heterogeneous, but suggest that N/H for the planetaries in the Clouds is comparable to values found in galactic planetary nebulae, while O/H is similar to the values in the H II regions of each Cloud. Osmer found that He/H was

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~ 50 % overabundanct in most of the planetaries he studied in both Clouds.

Spectrophotometric observations of supernova remnants in the two Clouds is still in its infancy, but new observations of LMC SNR Henize 49 by Dufour confirm the 1973 results of Osterbrock and Dufour. More observations of gaseous nebulae in the Magellanic Clouds are warranted, particularly of planetary nebulae and supernova remnants, in order to develop a more complete understanding of the chemical composition and evolution of the Clouds and of galaxies in general.

Lasker: The prime focus of the Cerro Tololo 4-meter telescope was used to assemble an atlas of the known supernova remnants (SNR) and the other nebulae in the Magellanic Clouds. A sample of these objects are published in Bull. R.G.O. (in press).

The stratification of [O III] λ 5007 with respect to [S II] λλ 6716, 6731 is discussed for the SNR's, N186 D and N206. The [O III] tends to lie outside the [S II] by about 3pc, and an explanation is sought in terms of shock flow through a region of density fluctuations.

A group of nebulae which are not known to be SNR's (i.e., do not have non-thermal radio emission) have [S II] strengths of the same order as Hα. These nebulae seem to have expansion velocities of ~ 30 km/sec, and it is argued that the ionization is radiative and that the additional heating required to explain the strong [S II] is furnished by shocks. From the data it is impossible to determine whether these shocks are driven by supernova blasts or by stellar winds.

31 August 1976

SCIENTIFIC MEETING

As a Joint Discussion between Commissions 28, 47 and 48 this will be reported in Highlights of the IAU, Vol. IV.

Reports of Working Groups

I. GALAXY PHOTOMETRY AND SPECTROPHOTOMETRY

The Group convened on September 1 with Dr H. D. Ables as the Chairman.

Dr M. Capaccioli was nominated as the new Chairman and elected unanimously by the members present. It was agreed that new members to the Working Group may be added by proposals to the Chairman.

The following papers were read:

J. Kormendy: Tidal Distension of Giant Elliptical Galaxies.
J. Kormendy: On the Universality of the Central Surface Brightness B(O) = 21.65 mag arsec^{-2} in Exponential Disks.
J.E.Solheim and G. de Vaucouleurs: Progress Report on Intermediate Band Photometry of Galaxies.
G. de Vaucouleurs and M. Capaccioli: Standard Photometric Profile of NGC 3379.
G. de Vaucouleurs, A. de Vaucouleurs and H. Corwin:Total magnitudes and Colors of Galaxies from Multiaperture Photometry.
R. Barbon, Benacchio and M. Capaccioli: Geometrical Parameters for NGC 3379/84.
S. van den Bergh: Photometry of Galaxies in the Hydra I Cluster.
F. Bertola and di Tullio: Sizes of Galaxies and Their Morphological Types.
R.G. Bingham: Electronographic Polarimetry Applied to M 82, NGC 4594 and NGC 1569.
H.D. Ables and P.G. Ables: B,V, Photometry of the WLM Galaxy.

II. THE MAGELLANIC CLOUDS

The Group convened on August 27 with B.E. Westerlund as Chairman.

Following the resignation of Drs J. Graham and D. Thackeray and the new elections the Group now consists of R.D. Davies, G. de Vaucouleurs, M.W.Feast, Ch. Fehrenbach, K. G. Freeman, S.C.B. Gascoigne, B.M. Lasker, B.Y. Mills V.C. Reddish, A. Toomre, S. van den Bergh, and B.E. Westerlund.

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Westerlund was reelected Chairman.
The following papers were read:

M. Azzopardi and J. Vigneau: The Structure of the Small Magellanic Cloud as Shown by the Supergiants.

A. Florsch: Some Arguments in Favour of a Great Depth of the Small Magellanic Cloud.

R.D. Davies: The Structure of the Clouds - Correlation between Optical and Radio Data.

A.G. Davis Philip: A Search for Stellar Members of the Magellanic Stream.

S.C.B. Gascoigne (read by D.S. Mathewson): NGC 2209.

B. Olander, H.B. Richer and B.E. Westerlund:The Carbon Stars in the Large Magellanic Cloud.

III. INTERNAL MOTIONS IN GALAXIES

The Working Group met at two successive sessions on the afternoon of August 27, 1976. The Chairman of the W.G. acted as chairman of the sessions. In a brief introduction the Chairman recalled the circumstances that had let to the formation of the W.G., during the Sydney Assembly.

Business matters were discussed at the start of the second session. It was agreed that the W.G. should continue to exist; P. Pişmiş was reelected chairman for a period of three years. It was suggested and agreed that a "subgroup" be formed to consider and propose a sample list of galaxies to be studied by means of all possible methods of data acquisition: radial velocities by optical-from stars and gas - by the 21 cm HI line, by radio recombination lines and possibly by molecular lines; distribution of luminosity by multicolor photometry (the latter to be carried out by the W.G. in Photometry of Galaxies) radio continuum data etc.

It is hardly necessary to emphasize that the results of such an endeavour will be extremely helpful in the study of the dynamics and the evolution of galaxies.

The following persons agreed to take part in this subgroup: Brosche, Cappaccioli, de Vaucouleurs (G), Einasto, Gouguenheim and Huchtmeier. The list of galaxies, representing all galaxy types will be discussed by this "Working Subgroup". The final list agreed upon will be distributed to persons on the mailing list of the W.G. on the Internal Motions in Galaxies or to anyone who expresses the desire to receive it. Suggestion as to the galaxies desirable to be included in the list will be welcome.

The W.G. will continue its program of distributing abstracts of papers in the process of publication.

The following papers on current work on the Velocity Fields in Galaxies were presented:

G. de Vaucouleurs, A. de Vaucouleurs and W.D. Pence: The Velocity Field of NGC 253 from Fabry-Pérot Interferometry.

S.M. Simkin: The Rotation Axis of 3C33 and Cyg A.

V.C. Rubin: Stellar Motions in Galaxies. The Barred Spiral NGC 3351 and the S0 Galaxy 3115.

M-H. Ulrich: Improved Optical Observations of the Outflow of Gas from the Nucleus of the Spiral Galaxy NGC 253".

H.M. Johnson: Recent Fabry-Pérot Observations of NGC 5128.

W. Huchtmeier: Recent H I Work of Sc Galaxies carried out at Effelsberg.

S. Faber: The Rotation Curve, Mass and Mass-to-light Ratio of NGC 4594.

P. Pişmis and L. Maupome: Remarks on Our Present Knowledge of Masses of Galaxies.

M. Capaccioli: Velocity Fields of the Early type Galaxies NGC 128, NGC 4125 and NGC 3998 from Absorption and Emission lines.

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IV. EXTRAGALACTIC SURVEYS FROM SPACE

A meeting was held on August 26 with H. Arp as Acting Chairman. About 40 astronomers participated. Three papers were presented:

G. Courtès: Three Steps to Extragalactic Surveys.

M. Capaccioli: Deep Photographic Survey from Spacelab.

K. Henize: Studies of an Allreflecting Schmidt Telescope.

The Working Group was then formed with R. Barbon as the Chairman and H. Arp as Vice-Chairman.

"This Working Group feels that a program of space astronomy for extragalactic and galactic research requires a variety of telescopes with varying capabilities and complementary roles. In addition to large telescopes with high resolution and great light-gathering power, it is also necessary to have optically fast wide-angle telescopes capable of surveying large areas of the sky in UV, visible and near IR wavelengths to limiting magnitudes and surface brightnesses fainter than can be achieved by ground based survey telescopes. Such telescopes can:

1) study extended objects with very faint surface brightnesses which are virtually impossible to reach with telescopes of large focal ratios, 2) explore for very faint galaxies and clusters of galaxies and 3) provide, in short time, UV and IR data of large numbers of objects over large sky areas of use to the entire astronomical community.

We therefore recommend that the space agencies of the IAU member nations give high priority to survey telescopes for space astronomy. In support of this recommendation it is the intention of this Working Group to promote discussions of the scientific objectives of such telescopes and of their impact on telescope design, and to aid in the coordination of study efforts by the various groups of astronomers interested in such telescopes and the data produced by them".

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COMMISSION 29: STELLAR SPECTRA (SPECTRES STELLAIRES)

Report of Meeting 25, 31 August 1976

PRESIDENT: A. A. Boyarchuk SECRETARY: J. P. Swings

First Session, 25 August 1976: Business Meeting

The following resolutions were adopted:
Resolution submitted to the General Secretary by Commissions 12, 14 and 29 (proposed by R. Garstang):

" The IAU highly values the activity of the United States National Bureau of Standards in the compilation and critical evaluation of atomic and molecular data, and considers these activities essential for the advancement of astronomy."

Resolution proposed by J. Pasachoff:

" Because the resonance lines of ionized magnesium at 2803 and 2795 A are being increasingly studied in the Sun and stars, we propose that these lines be denoted by their wavelengths rather than by any letter."

New Officers and Organizing Committee:

President: M. Hack, Vice-President: W. K. Bonsack, Organizing Committee:Y.Andrillat, A. A. Boyarchuk, C. O. R. Jaschek, J. Jugaku, R. J. Kovachev, D. C. Morton, J. P. Swings, K. O. Wright.

New Members: J. Boulon, C. R. Cowley, V. Doazan, M. R. Fernandes, L. Goldberg, D. L. Lambert, D. D. Locanthi, H. M. Maitzen, B. F. Peery, M. Plavec, D. Reimers, Th. Snow, J. Tech.O. Vilhu, R. Viotti, J. M. Vreux, P. Wehinger, W. W. Weiss, R. F. Wing, S. Wyckoff.

The following members have resigned: H. A. Brück

Deceased members: H. Kienle, S. V. Rublev

Future Symposia and Colloquia: HR diagram (Symposium, endorsed by Commissions 29, 35, 36, 37, 45). Organizing Committee: A. G. Davis Philip, P. Demarque, S. Strom, S. van den Bergh, K. Kodaira, I. Appenzeller, B.Paczynski, N. Walborn. To be held in Washington D. C.,U.S.A., November 2-5, 1977.

Turbulence in Stellar Atmospheres and Implications (Symposium, endorsed by Commissions 29, 36.) Organizing Committee: D. F. Gray, M. Marlborough, J. Linsky. To be held in Canada, in August 1979, on the occasion of Olin C. Wilson 70th birthday.

Colloquium on Photometry of Emission Line Stars to be held probably in Hvar (Yugoslavia) in October 1977. It is recommended that Commission 29 will sponsor this meeting only if spectroscopy of emission line stars is included. Also it is recommended to reduce the number of topics. The chairman of the Organizing Committee is J. Grygar.

Colloquium on Mass-loss and Evolution of O-type stars to be held in Western Canada in September 1977. The chairman of the Organizing Committee is P. Conti.

The President opened the discussion about the future form of the Commission Report. He reported that about 600 papers were written that are related to Commission 29; it is impossible to summarize all this work in a few pages. Studies of spectra of variable stars, binaries, radial velocity measurements, etc. are often included in the reports of Commission 29 as well as in those of Commissions 27 and 42. It was therefore suggested that Com-

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mission 29 should be concerned with the physical interpretation of spectra. M. Hack will write a letter to members of the commission asking for i) name of commission (e.g. opportunity to change it in "interpretation of stellar spectra") and ii) recommendation concerning the report.

Suggestions for "Newsletters": Requests are made that there should exist a circulation of some sort of newsletter, like the reports written by members of the organizing committee to the President of the Commission.This point should be included in the letter of M. Hack mentioned above.

Report on working groups: 1) Be stars. This working group will be continued since there are many people actively working in this field, as reported by R. Herman. 2) UV spectra. It provides a good link between commissions 29 and 44 for interpretation of data. Main work: the Joint Discussion of September 1, 1976 (report by L. Houziaux). 3) Line standards. G. Cayrel reports that she obtained no collaboration on this matter and therefore resigns. Only working groups 1) and 2) will remain.

Second Session, 31 August 1976: Scientific Meeting

The following short paper or reports of work in progress were presented:

A. B. Underhill: Identification in the ultraviolet spectra of O and B stars.
J. B. Swings: 8000-11000 A spectra of emission-line stars (in collaboration with Y. Andrillat, L. Houziaux and T. M. Vreux).
L. Gratton: A spectrophotometric investigation of K-giants (in collaboration with S. Gaudenzi, A. Giangrande, R. Nesci and C. Rossi).
M. Delcroix: Determination of atmospheric parameters of hot stars.
L. Luud: The infrared hydrogen emission lines in stellar spectra (in collaboration with M. Ilmas).

Other Activities of the Commission

One Joint Meeting was organized by the President with the cooperation of Presidents of Commissions 25, 27, 35, 36 and 42 on "Observational evidence of the heterogeneity of the stellar surfaces", August 27, 1976, (see Highlights of Astronomy, Vol.4.,1977).
D.J. Mullan: The heterogeneity of the solar atmosphere.
M. Hack: The heterogeneity of surfaces of magnetic Ap stars.
D. S. Evans: An analysis of the slow light variability of BY Draconis.
D. M. Popper: Star spots on AR Lac type stars.
J. M. Harvey, C. R. Lynds and S. P. Worden: Direct observations of the heterogeneity of supergiant discs.
R. E. Gershberg: On the spottedness and magnetic field of T Tau-type stars.

One Joint Meeting was organized in cooperation with Commission 36, 45 on "Classification criteria for non-normal stars" (August 28, 1976).

Two Joint Discussions were held with the participation of Commission 29: "Stellar atmospheres as indicator and factor of stellar evolution" with Commissions 35, 36, 44 (August 30, 1976) and "Impact of ultraviolet observations on spectral classification" with Commissions 44, 45, (September 1, 1976).

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COMMISSION 30: RADIAL VELOCITIES (VITESSES RADIALES)

Report of Meetings, 1976 August 26

PRESIDENT: R.F. Griffin SECRETARY: A.G. Davis Philip

The President welcomed those present at the meeting. He reported that Professor Heard, who had been expecting to attend and to present a paper, had been prevented from travelling as he was convalescing after a heart attack. The President's proposal that he should write a letter of greetings to Professor Heard in the name of the Commission, expressing the Commission's regret at his enforced absence and its best wishes for his continued recovery, was carried with acclamation. *

After some discussion - principally between the President and Professor de Vaucouleurs - the following changes in the composition of the Commission were agreed for the ensuing triennium:

President:	A.H. Batten
Vice-President:	M. Duflot
Organising Committee:	J.F. Heard*, A.G. Davis Philip, R.F. Griffin
Resigned:	A. Blaauw, R.F. Garrison, L. Gratton, E.K. Kharadze
Elected to membership:	C.T. Bolton, G. Hill, M. Imbert, E. Maurice, O.A. Mel'nikov, L. Prévot, E. Rebeirot

The Commission voted to adopt one rule: that no member should serve more than three consecutive terms on the Organising Committee unless he becomes the President or Vice-President; the retiring President should normally serve one term on the Organising Committee after his term of office.

Dr. Batten presented the report of the Joint Working Group set up in 1973 by Commissions 30 and 40 to study the problem of confusion between the two different uses of the symbol V_r to denote radial velocity.

The Commission unanimously agreed to forward as a resolution to the General Assembly the principal recommendation in the report, viz: "The practice of calling the quantity $c\Delta\nu/\nu_o$ a radial velocity, and denoting it by the symbol V_r, is confusing in extragalactic applications and should be discontinued. Astronomers who find it convenient to publish results in the form $c\Delta\nu/\nu_o$ should clearly indicate that they have done so. A new symbol might be coined for this quantity. We suggest V_ν". The Working Group, having completed its task, was discharged.

On the initiative of Professor de Vaucouleurs, a further resolution (also considered by Commissions 28 and 40) was approved for submission to the General Assembly, as follows: "That in the standard correction of extragalactic redshifts for solar motion with respect to the Local Group $\Delta V = 300 \cos A$, the definition of the solar apex be changed from $l^I = 57°$, $b^I = 0°$ to $l = 90°$, $b = 0°$, but that no change be made in the conventional value of the solar velocity $V_\odot = 300$ km s^{-1}."

The role of the Commission was discussed. Mme. Barbier spoke on "Catalogues of radial velocity" and Mme. Duflot on "La publication des vitesses radiales". The Commis-

*Unfortunately Professor Heard died on 1976 October 5 after a further heart attack.

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sion agreed to set up a new Working Group

to advise on the information which should be given in publishing new radial-velocity data, and

to advise on the procedure to be followed in finding the mean velocity of a constant-velocity star for which there is more than one value in the literature.

Mme. Barbier was appointed as Chairman of the Working Group, and Dr. Batten, Mme. Duflot, Professor Evans and Dr. Griffin as members.

The following scientific topics were discussed:

Standard stars

Bolton (for Heard): report of continuing observations of the standard stars adopted in 1973.

Maurice: Concerning a possible zero-point error in Evans' southern standards.

Standard wavelengths

Batten: Report of recent work at Victoria.

Radial-velocity spectrometers

Mayor; Wright

Reduction of photographic spectrograms using a PDS microdensitometer

Bolton

Automated reduction of Fabry-Pérot interferograms of nebulae and galaxies

de Vaucouleurs

Radial velocities in the galactic-pole fields

Hilditch; Upgren; Griffin

Radial-velocity measurements with a 60-cm objective prism

Fehrenbach

Measurement of globular-cluster radial velocities with a pressure-scanned Fabry-Pérot

Shawl

COMMISSION 31: TIME (L'HEURE)

Report of Meetings 25, 26, 27, 28, 30 and 31 August, 1976

PRESIDENT: H. Enslin SECRETARY: H. F. Fliegel

25 August 1976

Participants stood in silence in memoriam of A. Gougenheim, M.R. Madwar, J. Verbaandert, and F. Zagar; the latter, late President of Commission 31 during the term 1968 - 1970.

ADMINISTRATIVE MATTERS; INTERNATIONAL COOPERATION

The Commission unanimously approved the nomination of A. Orte as new President, and of S. Iijima as new Vice-President. The new Organizing Committee members were approved. There were no objections against the names of several new members to the Commission who had applied, or been proposed, for membership. The Commission took note of the resignation of P. Bakulin, H.U. Sandig, B. Sternberk, and M.M. Thomson.

The President presented a list of "Subjects to be considered by Commission 31". Following comments, he agreed to present, during a later session, an amended version. It was approved that the list be published in the Proceedings and thus brought to a wider public.

B. Guinot, BIH Director, discussed general considerations on the generation of TAI and the operation of the UTC system. He noted that time comparison improvements would be desirable to improve the establishment of TAI. Details of the BIH's work are given in its Annual Reports and also in the Report of the Commission. It was unanimously agreed to include a note of appreciation for the BIH's work in the Proceedings of the Commission (see final item in this Report).

J. Terrien, BIPM Director, gave an account of the resolutions concerning TAI and UTC passed by the 15th CGPM (1975), which has also recommended that the value of 299792458 m/s be used for the speed of light. In J. Terrien's opinion, this value will remain unchanged.

The BIH Directing Board's Chairman, H.M. Smith, presented a paper "Proposed Revision of the Terms of Reference of the BIH", and commented that a new resolution on the BIH's work has been made necessary by the BIH's additional responsibilities. He did not believe that the BIH should be made responsible for reporting matters of legal time. It was decided to discuss those parts of the draft which refer to the determination of the Earth's rotation, during a joint session with Commission 19.

Wm. Markowitz reported on the 1974 CCDS meeting. He reminded of the recommendation adopted by Commissions 4 and 31 in Sydney that TAI be changed by 32 s to bring ET and TAI in close accord. The CCDS discussed this proposal, but referred it back to the IAU. It was noted that a proposal that the change should not be made was now before the IAU.

H.M. Smith reviewed the activities of CCIR Study Group 7. At the 1976 meetings of Study Group 7, it was agreed that the Interim Working Party 7/1 continue with extended tasks: collation of users' requirements and study of digital time codes. A new Interim Working Party, 7/3, was created which is concerned with the reduction of mutual interference in the frequency bands allocated for time signal and standard frequency emissions. The speaker pointed out that the IAU should react to CCIR Opinion 36-1 which invited the IAU to consider Universal Time as an angular measure.

The President outlined briefly Draft Resolutions Nos. 1 - 3, distributed in advance of the General Assembly. The Commission approved an additional meeting on 26 August to discuss draft resolutions, thereby providing directions for the drafting committee chaired by H.M. Smith.

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26 August 1976

Two joint meetings were held with Commissions 4 and 8 (see Report of Commission 4); one joint meeting with Commissions 4, 8, 19, and 40; and one joint meeting with Commission 19 (see Report of Commission 19).

27 August 1976

ADMINISTRATIVE MATTERS

The following names were agreed upon for consultantship during the term 1977 to 1979; C.O. Alley, J.A. Barnes, G. Becker, C.C. Costain, R. Lake, S. Leschiutta, P. Morgan, P. Mourilhe Silva, A.R. Robbins, J.M. Steele, J. Terrien.

The amended list of the "Subjects to be considered by Commission 31" was unanimously approved after slight changes suggested by Commission members (see last page in this Report).

A.M. Sinzi reported about his many efforts aimed at the establishment of a worldwide office responsible for collecting and providing information about legal and daylight saving times. As a result, the International Hydrographic Bureau has acted as such an office and has published, once or twice a year, such information in the monthly Hydrographic Bulletin, but quite incompletely, as yet.

DISCUSSION OF DRAFT RESOLUTIONS

Draft Resolution No. 1, use of GMT and UT, was presented in 2 versions. Main points of argument concerned the questions as to whether or not it should be recognized that GMT be used in the sense of UT1 in almanacs, and that UT be used in place of UT0, UT1, UT2 and UTC in cases where the distinction between them is not necessary. There were also proposals that the notation UT should imply UT1 exclusively.

When discussing Draft Resolution No. 3, designations and notations for time concepts and time scales, it appeared that "time concept" is interpreted most differently: therefore, it was agreed to drop that description and all clauses referring to time concepts.

Discussion of Draft Resolution No. 2, adjustment of the TAI frequency, was confined to the importance of the uniformity and accuracy of TAI in consideration of the new dynamical time scale, and the date to be recommended for the adjustment. It was noted that the introduction of the steering of TAI could be postponed to some later date after the frequency adjustment was made.

A draft reply to CCIR Opinion 36-1 was presented as Draft Resolution No. 4. No final decision was taken as it was intended to consider the drafts, after revision, during later meetings to be held jointly with Commission 4.

28 August 1976

Two meetings were held, the first jointly with Commission 4.

DISCUSSION AND VOTE ON RESOLUTIONS

The President read the revised draft of Resolution No. 2. Discussion related to the way of explaining the problem and also the necessity of adjusting the frequency of TAI as the latter would cause great inconvenience for users. The decision was deferred to a later meeting, subject to an amended draft.

The final draft of the BIH Statutes was introduced and unanimously approved by Commission 31 (see Resolution No. 7 of the General Assembly).

SCIENTIFIC PRESENTATIONS

A.M. Sinzi reviewed the prediction, observation and reduction of lunar occultations, and the subsequent evaluation of ET from the data. He demonstrated the results of analyses of ET - TAI from occultation data extending over 15 years. Scattering of up to ±0.4 s of the yearly mean values of ET - TAI may be due to the ephemeris used.

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L.V. Morrison presented a paper "Comparison of ET(Moon) and ET(Mercury) for the Period 1677 - 1973". The UT of the observation of internal contacts for the transit of Mercury was compared with the ET calculated from the motions theories of Mercury and the Earth. The resulting ΔT's were compared with other ΔT's derived from lunar observations; the tidal acceleration of the Moon thereby found was -26" ± 2" cy^{-2}.

C.O. Alley reported an atomic clock General Relativity experiment using a slow flying aircraft for 15 h at 10^4 m on 5 independent flights, and 2 interchangeable sets of atomic clocks. Typical flight data: measured, +47 ± 1.5 ns; calculated, +47.1 ± 0.25 ns = +52.8 ns (gravitational potential) - 5.7 ns (relative velocity).

J.D. Williams gave an account of relativity corrections as used in lunar laser ranging modelling. The corrections for significant periodic effects to be applied to the earth-based clocks to convert them to a solar system barycentric frame can be classified in yearly (1658 μs), monthly (1.6 μs), and daily (2.0 μs x cos Φ) terms.

The first lecture, 2nd meeting, delivered by G. Winkler on "Time Synchronization via Satellites", outlined methods for determining geometric and ionopheric corrections and reviewed various types of satellites used for clock comparisons, with estimates of accuracy: 0.1 μs actually reached, 0.1 ns perhaps possible with new systems.

P. Morgan demonstrated phase comparison results made in Australia between a ground oscillator and satellite signals on one frequency with residuals varying from 0.8 to 1.5 μs. Agreement of transportable clock versus satellite time transfer between USNO and Australia has been better than 1 μs.

M. Granveaud described the algorithm used by the BIH since 1973 June, for computing TAI from data of - at present - about 80 clocks, the weights of which are determined iteratively. Provision is taken in order to preserve the uniformity of TAI.

J. Azoubib explained the principles which underly the steering of an atomic time scale, by the use of the data of primary standards to improve both its accuracy and long term stability. The steering of TAI will cause no difficulties for the BIH.

30 August 1976

There were two joint meetings with Commission 4.

SCIENTIFIC PRESENTATION

G. Becker reviewed the characteristics of 6 primary caesium standards, 3 of them being operational. The uncertainty of the operating standards is estimated to be about 1×10^{-13}. Improvement to about 2×10^{-14} is envisaged.

DISCUSSION AND VOTE ON RESOLUTIONS

Resolution No. 2, as given below, was adopted after some discussion as to how the frequency adjustment of TAI should be formulated.

The President of Commission 4, R.L. Duncombe, took the chair, for a vote by Commission 4 members only, on the proposal that the new dynamical time scale should be specified with respect to TAI on 1977 January 1, not 1958 January 1, as provided for in Recommendation 5(a), Joint Report of the Working Groups of Commission 4. After some discussion, the proposal was approved.

The President of Commission 31 resumed the meeting by introducing Draft Resolution No. 4. An extended discussion took place as to whether or not the statement expressed in the clause 3(a) was true, and if so, whether it was necessary to include it in the Resolution. Regarding Resolution No. 3, there was strong debating about the proposal that, in order to be logically consistent with other definitions, the notations TU0, TU1, TU2 should be adopted and not UT0, UT1, UT2. The counter opinion was that this would increase confusion. Discussion of Resolution No. 1 concentrated on the point concerning retention or deletion of the clause concerning discontinuation of GMT. Resolutions Nos. 1, 3, and 4 were adopted as given below.

31 August 1976

A joint meeting was held with Commission 19 (see Commission 19 Report).

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Resolutions

RESOLUTION NO. 1 BY COMMISSIONS 4 AND 31

Considering
the desirability of a clarification of the use of Greenwich Mean Time (GMT) and Universal Time (UT),

Notice
(a) that GMT and UT are used in the sense of UTC for Statutory, communications, civil use and other purposes in which maximum precision of timing is integer seconds,
(b) that GMT and UT continue to be used in the sense of UT1 as the independent argument of almanacs for astronomical navigation and surveying,

Recognize
that UT may be used in the place of UT0, UT1, UT2 and UTC in cases where the distinction between them is not needed,

Urge
that GMT be replaced by the appropriate designations, and

Recommend
that the unambiguous notations UT0, UT1, UT2 and UTC be used in all scientific publications whenever it is necessary to distinguish between them.

RESOLUTION NO. 2 BY COMMISSIONS 4 AND 31

Considering
(a) that the IAU has adopted for the dynamics of the solar system a new time scale based on the second of the International System of Units (SI),
(b) that the new time scale is closely related to International Atomic Time (TAI) and that high uniformity and accuracy in TAI are desired, and
(c) that it has been established by reference to improved primary standards that the present duration of the scale interval of TAI differs from the SI second at sea level by $(10 \pm 2) \times 10^{-13}$ s,

Recommend
that a single step adjustment of $+10 \times 10^{-13}$ s be made at $00^h00^m00^s$ TAI of 1 January 1977 to bring the duration of the scale interval of TAI into close agreement with the SI second at sea level, and that thereafter the uniformity and accuracy of TAI shall be maintained.

RESOLUTION NO. 3 BY COMMISSIONS 4 AND 31

Considering
(a) that various time scales are in current use which are based, for example, upon the rotation of the Earth or upon quantum transitions,
(b) that agreed designations of the time scales are desirable,
(c) that the time differences between time scales must be expressed unambiguously,
(d) the recommendations of the CGPM and CCIR,

Recognizing
that the designations of the time scales are also used as symbols for the expression of time instants read from the respective scales,

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Recommend
(1) that the following notations be used in all languages,
(2) that the following rules be applied.

Time Scales

1. Atomic Time

TAI (International Atomic Time) is the time scale established by the BIH on the basis of atomic clock data supplied by cooperating institutions;

TA(i) is an atomic time scale established by the institution "i".

2. Universal Time

UT0(i) is the mean solar time counted from midnight of the origin of longitudes obtained from direct astronomical observation at the observatory "i";

UT1(i) is UT0(i) corrected for the effect of the polar motion at the observatory "i";

UT2(i) is UT1(i) corrected for the effect of the seasonal variation as published by the BIH, of the Earth's rotation.

The specification of the observatory may be omitted from UT1 and UT2, if it can be inferred unambiguously from the accompanying text. In the case of the BIH, this specification is usually omitted.

3. Coordinated Universal Time

UTC ist the time scale maintained by the BIH which forms the basis of a coordinated dissemination of time signals and standard frequencies and has been recommended by the CGPM to be used as the basis of civil time. The UTC scale corresponds exactly in rate with TAI and differs from it by an integer number of seconds. It is adjusted by the insertion or deletion of seconds to ensure approximate agreement with UT1.

UTC(i) is a time scale realized by the institution "i" and adjusted to maintain agreement with UTC.

Where there is any possibility of misunderstanding, the designation UTC(BIH) should be applied.

Note. UT may be used to designate a time scale related to the diurnal rotation of the Earth in cases where the distinction between UT0, UT1, UT2 or UTC ist not needed.

RESOLUTION NO. 4 BY COMMISSIONS 4 AND 31

1. Take notice of CCIR Opinion 36-1 on Time Scales which invites the IAU to consider whether the UT scale could be considered henceforth as an angular measure and should be differentiated accordingly,

2. Agree that Universal Time may be considered as an angular measure of the rotation of the Earth, but

3. Are of the opinion

(a) that a useful time scale is generated by any process which enables dates to be assigned to events,

(b) that the designation Universal Time as a time measure is firmly established and of such great convenience in astronomy, geodesy, astronomical navigation and related applications that it would not be desirable to attempt to change this practice and that considering the need to express differences between other time scales, it is necessary to retain the existing designations in hours, minutes and seconds.

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RESOLUTION NO. 5 BY COMMISSIONS 19 AND 31

This was adopted by the General Assembly specifically (Resolution No. 7).

Subjects to be considered by Commission 31

1. Fundamentals
(a) Time concepts
(b) Time units, time scale unit intervals and multiples
(c) Definition and nomenclature of time scales
(d) Legal aspects of time

2. Investigations about dynamical time scales, atomic time scales, and Coordinated Universal Time

3. Time determination
(a) Clocks and frequency standards
(b) Auxiliary equipment
(c) Overall review of the determination and coordination of Universal Time (in cooperation with Commission 19, which has the major responsibility in the determination of rotational time)

4. Time dissemination and synchronization
(a) Time signals, standard frequencies, time codes
(b) Methods of precise time dissemination
(c) Time coordination and synchronization

5. Applications of time
(a) Applications of time and frequencies to astronomy, space research, Earth sciences, and navigation
(b) Information about time and frequencies for users

6. Relativistic effects on time measurements

7. Cooperation with international organizations concerned with time

Acknowledgement

Commission 31 of the IAU wishes to extend its sincerest gratitude to the Director of the BIH, Dr. B. Guinot, and his staff, in appreciation of the effective work of the BIH and the rapid publication of results.

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COMMISSION 33: STRUCTURE AND DYNAMICS OF THE GALACTIC SYSTEM (STRUCTURE ET DYNAMIQUE DU SYSTEME GALACTIQUE)

Report of Meetings 25, 26, 27, 30 and 31 August 1976

PRESIDENT: L. Perek
VICE-PRESIDENT: F.J. Kerr

25 August 1976

Joint Discussion 1. Galactic Structure in the Direction of the Polar Caps. (Included in the Highlights of Astronomy 4.)

26 August 1976

Business Meeting of Commission 33. The new officers and Organizing Committee members were duly elected. Guidelines and rules of operation of the Commission as printed in IAU Trans. XIV B, p. 200, were deemed sufficient. It was agreed that the tradition of detailed Commission reports should be continued. The co-options of new members were endorsed and additional new members were elected. Proposals for new Symposia were discussed.

W.P. Bidelman reported about the main results of Colloquium No. 35, The Compilation, Critical Evaluation and Distribution of Stellar Data.

D.S. Matthewson presented a paper on the Magellanic Stream and discussed the possibility of its tidal origin.

27 August 1976

A. Large-scale Distribution of Stars and Total Mass

Invited speakers were:

- S. van den Bergh: The Bulge and Disk of the Galaxy.
- M. Schmidt: The Halo of the Galaxy.
- J. Einasto: The Mass of the Galaxy.

The speakers discussed the role of dust in various types of galaxies, the mass of the visible part of the halo of the Galaxy and the total mass of the Galaxy. Also under discussion was the relation of population II to the hypergalaxy formed by the Galaxy and its several neighbouring stellar systems.

B. Informal Presentations

R.H. Miller showed a film of a three-dimensional stellar system as it evolved from an initial stage of a spherical shape in rotation.

T.A. Agekian analyzed the role of the gradient of directions of motion along the normal of the trajectory in the meridional plane of a stellar system.

W.J. Luyten reported on a survey by G. Hill of proper motions of 43,000 stars in and around the Hyades and Pleiades clusters.

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A.R. Upgren, investigating the dynamics of young and old stellar populations from dK2-M2 stars, found outward motions of young disk stars.

30 August 1976

Large-scale Distribution of Interstellar Matter
Joint Meeting with Commission 34

Invited speakers were:

- W.B. Burton: Distribution of CO and the General Morphology of Hydrogen.
- J.P. Puget: Information from Gamma-ray Studies.
- L. Hart: Recombination-line Observations of Ionized Hydrogen.
- W.W. Roberts: The Distribution in the Context of the Density Wave Theory.

The common theme of the meeting was the discussion of new discoveries in a region at 5-7 kpc from the centre. The carbon monoxide, in contradistinction to neutral hydrogen, seems to be confined to distances below 8 kpc in a rather clumpy distribution. The gamma-rays and the ionized hydrogen show most prominent peaks at 5-6 kpc. All these effects can be understood within the frame of the density-wave theory which predicts that the spiral shock-front would be strongest in that part of the Galaxy.

31 August 1976

Non-circular Motions in the Galaxy
Joint Meeting with Commission 34

Invited speakers were:

- B.J. Robinson: Motions of Molecular Clouds in the Nuclear Disk.
- P.G. Mezger: Radial Velocities of the Ionized Gas in the Centre of the Galaxy (presented by T. Pauls).
- E.R. Wollman, T.R. Geballe, J.H. Lacy, C.H. Townes, D.M. Rank: Spectral and Spatial Resolution of the 12.8 mu Ne II Emission from the Galactic Centre (presented by E.R. Wollman).
- S.V.M. Clube: The Galaxy as an Expanding Spiral.
- F.J. Kerr: Large-scale Motions of H I in the Galaxy.
- M.S. Roberts: H I Motions in the Andromeda.
- G. Monnet: Analysis of the Expansion Along the Minor Axis in M 31, M 33 and the Galaxy.
- J.H. Oort: A Dark Arm in M 31 with a Large Radial Motion.

There are many recent observations of significant non-circular motions in the Galaxy as well as in the Andromeda nebula. Their interpretation by Clube as a general expansion, mainly supported by a discussion of proper motions from the Lick Pilot Survey, was opposed by Kerr and Oort who quoted important evidence that the local standard of rest has a zero radial velocity with regard to the galactic centre, such as a prominent absorption feature at Sgr A or the symmetry of radial velocities of distant planetary nebulae.

The success of the above meetings is due to the efforts of the authors of invited papers and of the contributors to discussion. We record here our appreciation to M.F. McCarthy S.J. and his organizing committee for the preparation of the excellent programme of the Joint Discussion, and to F.J. Kerr and J. Einasto for the organization of the meetings on Large-scale Distribution of Interstellar Matter and of Stars and Total Mass respectively.

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COMMISSION 34: INTERSTELLAR MATTER AND PLANETARY NEBULAE (MATIERE INTERSTELLAIRE ET NEBULEUSES PLANETAIRES)

Report of Meetings, 25 - 31 August 1976

PRESIDENT: Hugo van Woerden.
VICE-PRESIDENT: George B. Field.

Business Session, 27 August

The President spoke briefly in commemoration of two outstanding deceased members: S.B. Pikel'ner and R. Minkowski. Pikel'ner's major contributions include work on the galactic halo, on the two-phase model of the interstellar gas, and several books; he was President of the Commission in 1964-67. Minkowski is noted for his work on planetary nebulae, supernovae and supernova remnants, and the identification of radio sources; also he supervised the famous Palomar Observatory Sky Survey. Members stood in silence for a minute in memoriam.

Membership

The membership list being submitted to the General Secretary contains over 300 names. It was composed of: the membership approved by the 1973 General Assembly, minus a few withdrawals, plus additions proposed by members of the Organizing Committee and by National Committees of Astronomy, plus applications made by individual IAU Members (mostly during the current Assembly); the applications have not been screened. President and Organizing Committee consider the present list too long to be practical, and suggest a reduction by asking members to reapply, say, every six years.

Following considerable discussion, the Commission authorized its new President to arrange for a reduction in membership, after proper consultation with the Organizing Committee and with Commission members.

Organizing Committee

The Commission agreed to nominate the following Organizing Committee (OC) for 1976-79: G.B. Field, President; V. Radhakrishnan, Vice-President; L.A. Higgs, G.S. Khromov, J. Lequeux, B.T. Lynds, M. Morimoto, D.C. Morton, M. Peimbert, H. van Woerden, B. Zuckerman.

Scientific Sessions during current Assembly

The program for these sessions, which consists mainly of invited reviews, was drawn up after consultation with the OC and with Presidents of other Commissions. One session of 1½ hours is being devoted to selected short contributions; a few others are presented in the appropriate review sessions. The selection of these contributions from some 35 submitted was made by the OC.

Members expressed their appreciation of the size, quality and general setup of the program. However, they would prefer more time for contributed papers, perhaps 4-5 hours in total.

The reports of sessions will contain summaries of the invited reviews and (briefly) of relevant discussion; contributed papers will be mentioned by title.

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Symposia and Colloquia

Dr. Terzian summarized plans for IAU Symposium No.76, "Planetary Nebulae", to be held at Ithaca (NY, USA) in June 1977.

The President reviewed plans for various meetings now under consideration: an IAU Colloquium on Photometry of Emission-Line Objects (Hvar, Jugoslavia, 1977 or 1978); an IAU Symposium on Large-Scale Characteristics of the Galaxy, to be sponsored by Commissions 33, 34 and 40 (Maryland, 1978 or 1979), an IAU/URSI Symposium on Interstellar Molecules, to be sponsored by Commissions 34 and 40 (Ottawa, 1979). The Commission strongly endorsed both proposed symposia.

Designation of Planetary Nebulae

Following a proposal by Drs. Perek and Kohoutek, the Commission adopted the following resolution:

"In order to keep up a unified system of designations of planetary nebulae, consistent with the "Catalogue of Galactic Planetary Nebulae" (Perek, Kohoutek, 1967) new designations will be approved by the Organizing Committee of Commission 34 and will be published. Dr. L. Kohoutek will prepare the first list of new designations since the appearance of the Catalogue and will transmit it to the President of Commission 34 before the General Assembly of 1979."

Bibliography of Non-Stellar Objects

Drs. A. Acker and M.C. Lortet reported on the efforts of the Strasbourg Centre for Stellar Data in compiling and distributing information pertaining to a Bibliography of Non-Stellar Objects. The Commission took note of these efforts and suggested that Drs. Acker and Lortet prepare a brief report, for possible inclusion in the IAU Information Bulletin after consultation with the President of Commission 34.

Scientific Sessions

The following pages give brief summaries of the invited reviews and of the discussion; contributed papers are mentioned by title only. The reviews will be published in extenso in a book, "Topics in Interstellar Matter", by Reidel.

Session 1: The Hot Interstellar Gas Phase

Joint Meeting of Commissions 44 and 34, held 25 August 1976. Chairman: G.B. Field; Secretary: E.B. Jenkins.

OBSERVATIONS of O VI, Edward B. Jenkins.

A large proportion of the early-type stars observed by the *Copernicus* satellite show evidence of O VI ions in the lines of sight. The absorption profiles are always broader than normal interstellar lines, which suggests the ions are formed by collisions in a very hot gas ($T \sim 4 \times 10^5$ K), rather than from nonthermal processes on ordinary, cool gas, such as interactions with cosmic rays or X-rays. The lack of conspicuous amounts of N V and S IV indicates there is relatively little gas at $T < 2 \times 10^5$ K, where the radiative cooling times are short.

Present evidence seems to disfavour a close relationship between the hot gas and the particular stars observed; practically no correlation between stellar and gas radial velocities is present, and the velocities and column densities of O VI seem unrelated to the stars' spectral types. While the amount of O VI is correlated with a star's distance, there is a large scatter in average density from one line of

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sight to the next. The measured densities are consistent with a density n(O VI) = 2.8×10^{-8} cm^{-3} in the galactic plane and an exponential dropoff with a scale height of about 300 pc. A conspicuous overabundance of O VI is seen near the Vela supernova remnant. Aside from that, there seems to be no correspondence between the distribution of coronal gas and other noteworthy regional properties, such as local galactic structure.

O VI profiles with larger column densities generally have a larger velocity spread, which is consistent with our viewing a blend from several coronal-gas regions, each with its own random velocity of about 25 km s^{-1} and N(O VI)~10^{13} cm^{-2}. If these regions have a pressure not much greater than the general interstellar gas, they must occupy at least a few percent of the total volume of space in our region of the Galaxy.

OBSERVATIONS OF THE SOFT X-RAY BACKGROUND, Donald P. Cox.

During the last several years, the study of celestial soft X-rays (~1/4 keV) has shown that they are very likely galactic, diffuse in origin, and thermal.

To date, the Wisconsin group has mapped the surface brightness of 60% of the sky. Several things have been noted (e.g. W. Sanders, thesis): (1) There are interesting correlations between some bright areas and HI column-density features. (2) There is a general but imprecise anticorrelation between surface brightness and N_{HI}, but the dimmer regions do not show the spectral hardening characteristic of absorption. (3) The surface brightness tends to correlate with measured interstellar O VI absorption column density for distant stars at medium and high latitudes.

The limited amount of spectral information available from proportional counters has led to the following conclusions (e.g. P. Burstein, thesis): (1) No single-temperature interstellar plasma has a spectrum consistent with the observed pulse-height distributions, even with various spectral changes possible from absorption. (2) Combination models can be made to fit with two or more temperatures. For two-component models the higher temperature must be at least 2×10^6 K and the lower one in the range (2 to 8) x 10^5 K. It is not yet clear whether the distribution function in temperature is essentially bimodal. (3) The two-component models can be subjected to O VI column-density and pressure constraints; in this case, the easiest accommodation occurs with the lower temperature around 6×10^5 K. The pressures of both components are then found to be at least 10^{-12} dyne.cm^{-2} or P/k = 2nT~$10^4 cm^{-3}$K. (Burstein, Borken, Kraushaar, and Sanders, Ap.J., in press)

A recent reference that covers these matters is Williamson, F.O., Sanders, W.T., Kraushaar, W.L., McCammon, D., Borken, R., and Bunner, A.N. 1974, Ap.J. (Letters), 193, L133.

NATURE AND ORIGIN OF THE HOT GAS, C.F. McKee.

Supernova explosions in a cloudy interstellar medium (ISM) produce a large volume of hot gas (HIM) in the disk of the galaxy with T $\gtrsim 3 \times 10^5$ K (Cox and Smith, 1974, Ap.J.(Letters) 189, L105; McKee and Ostriker, 1975, Bull.Amer.Astr.Soc. 7, 419). The evolution of supernova remnants (SNR) in the resulting 3-component medium (cold clouds, warm clouds of 10^4 K, and HIM) is altered by evaporation of the clouds, which injects a significant amount of mass into the hot interior of the SNR (McKee and Ostriker, 1975; L. Cowie, 1976, Thesis, Harvard). The onset of the dense shell phase of SNR expansion is hastened by the higher internal density resulting from evaporation and by the enhanced cooling in the conductive interfaces between the clouds and the HIM.

The density and temperature of the HIM are determined by energy balance (SN input = radiative loss) and mass balance (cloud evaporation rate = dense shell formation rate), with typical values being (n,T) = ($10^{-2.5}$ cm^{-3}, $10^{5.7}$ K) (McKee and Ostriker, 1975). The resulting pressure P/k = $10^{3.5}$ K cm^{-3} agrees with 21-cm and H_2 determinations. The predicted mean density of O VI in the HIM is ~10^{-7} cm^{-3}, significantly greater than observed; but much of the O VI should have too high a velocity dispersion to be readily detectable. Soft X-ray emission arises in large

SNR (R ~ 170 pc) near the cooling point, where the pressure is higher than average; the predicted intensity agrees with observation.

NATURE AND ORIGIN OF THE HOT GAS, R. McCray.

No summary available.

SUMMARY OF COMMENTS AND DISCUSSION

One participant (unidentified) questioned whether the exceptionally low abundance of O VI toward the star γ Cas places constraints on our interpretation of the filling factor of the hot gas. Jenkins replied that the known irregulatiry in the distribution of coronal material makes a general interpretation from a single measurement untrustworthy, but the γ Cas measurement makes the notion that we are immersed in a coronal region less tenable. A comment was made that the softest X-ray emission was more isotropic than the background at higher energies; McKee and Cox suggested this may imply we are inside a region of hot gas (perhaps too hot to produce O VI toward the very nearest stars). Jenkins raised two possible objections to this viewpoint: one being the observation of backscattering of solar Lα emission by local neutral hydrogen, and the other being a suggestion by Parker that the constancy of the cosmic-ray flux with time (based on meteoritic evidence) would preclude our being recently enveloped by a bubble of coronal material.

Field asked about the preponderance of negative velocities seen in an early survey of O VI. Jenkins replied that the laboratory wavelengths of the transitions are poorly known, but that a reconsideration of presently available data seemed to favour an upward revision of all the older velocities by about 6 km s^{-1}. McCray emphasized that better laboratory measurements of wavelengths still need to be made, since the lack or presence of negative velocities is crucial to deciding between circumstellar or general interstellar origins of the gas.

Radhakrishnan asked McKee what was a typical radius for a supernova remnant when breakup occurred. McKee replied this radius should be on the order of 170 pc. Jenkins questioned McCray on the alteration of shell geometry by a motion of the star with respect to the surrounding material. McCray said this problem has been considered, and he briefly showed a diagram of the situation.

The session chairman encouraged McKee and McCray to engage in a direct debate on their opposing viewpoints on the origin of the coronal gas. During this confrontation McKee questioned why we do not see more compelling observational evidence for the widespread presence of distinct shells around the hotter, more luminous stars. He suggested that dense blobs of cool material inside the stellar wind region may quench the formation of the shell through losses by conduction. McCray suggested we should investigate whether or not such density inhomogeneities are swept out by the stellar wind, or do they remain inside the cavity?

Van der Laan expressed a general caution that if we thought of the filling factor of hot gas not being very much less than unity, we might have trouble understanding the establishment of a "grand design" in galactic structure.

Session 2/3: Interstellar Molecules and Dust

Joint Meeting of Commissions 34, 40 and 44, held 25 August 1976. Chairmen: B.J. Robinson and A.D. Code; Secretary: J.M. Greenberg.

OBSERVATIONS OF MOLECULAR CLOUDS, B. Zuckerman.

Since the 1973 IAU meeting about 15 new interstellar molecules have been detected, and a number of unidentified lines have been identified both astronomically and in the laboratory. HCO^+, HNC and N_2H^+ are the most interesting of these. Various observations suggest that only 10-30% of the interstellar carbon is contained in CO.

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I will discuss giant molecular clouds seen near bright HII regions and other clouds not associated with luminous stars. Many detailed studies exist, for both kinds of cloud. For example, M17 has been observed by Lada and W49 by Mufson and Liszt. Dark clouds not associated with bright stars have been studied, for example, by Evans and Kutner, Blair and Encrenaz in molecular lines, by Strom and co-workers in the infrared, and by Gilmore and Brown in the radio continuum.

Questions of the dominant motions in these clouds were considered by Liszt and co-workers, Zuckerman and Evans and Milman who discussed the relative virtues of cloud models dominated by systematic or turbulent motions. The absence of self-reversed ^{12}CO profiles was used as an argument in favour of systematic motions with $v \propto r$. Recently self-reversed lines have been observed in about a half-dozen clouds suggesting that, at least in such clouds, systematic motions are not large and/or not monotonic. Loren and Snell in a recent paper argue that certain asymmetries in the ^{12}CO and ^{13}CO profiles suggest that four clouds showing self-reversals are free-fall collapsing according to a $v \propto r^{-1/2}$ law. There are, however, various theoretical and observational problems with this interpretation, particularly when H_2CO absorption profiles are compared with the CO profiles.

Very recent results on the Orion molecular cloud concern both the very large and very small scale. Kutner, Evans and Tucker have made maps in ^{12}CO, ^{13}CO and H_2CO (2-mm emission) which extend from the Kleinmann-Low Nebula in the south to NGC 1977, suggesting that this nebula is ionization-bounded by the molecular cloud. Various optical, infrared, and radio measurements could be made near the interface of HII region and molecular cloud. The H_2CO map shows several fragments of the molecular cloud separated by ~ 1 pc; each fragment contains ~ 10^3 $M_\odot$. Based mainly on observations of M17, Elmergreen and Lada suggest fragmentation on a scale of ~ 20 pc, comparable to the separation of subgroups in OB-associations noted by Blaauw.

At the Kleinmann-Low Nebula Zuckerman, Kuiper and Kuiper have found ^{12}CO emission over a total velocity range of at least 150 km/s. This localized high-velocity emission (extent $\lesssim 1'$) is probably associated with pre-, rather than post-, main-sequence objects and probably represents extensive mass outflow rather than inflow. The implied outflow of mass (~ 10^{-3} $M_\odot$/yr) and momentum is, however, quite large if it is to be supplied by a cluster of young stars.

Discussion Burton: Can one eliminate side-lobe contributions to the broad CO profiles? Zuckerman: The broad wings disappear away from the K-L Nebula.

ISOTOPIC COMPOSITION OF INTERSTELLAR CLOUDS, C.H. Townes.

The observation of microwave spectra of molecules in interstellar clouds allows separation and detection of the lines of isotopes of many of the more common elements. Comparison of intensities of isotopic lines shows that the relative isotopic abundances for C, O, S, N, and Si are generally rather similar to those found on Earth. However, there are interesting and provocative differences.

Special conditions of opacity, of cloud structure, of excitation, or of chemical fractionation of isotopes can confuse and make very uncertain the determination of isotopic abundances from the intensities and shapes of molecular lines. Opacity high enough to make relative abundances of isotopes difficult to determine with precision is commonly encountered, and so is chemical fractionation at least in the case of the hydrogen isotopes. The extent of resulting uncertainties is still unclear. However, careful selection and interpretation of measurements and comparison of different spectra seem to allow the determination of relative isotopic abundances to a useful precision and degree of certainty. The results indicate that the $^{12}C/^{13}C$ ratio is generally about 45, one-half that found on Earth, but is as low as about 20 in the Sgr A and Sgr B clouds, and as high as about 80 in some other clouds. Such apparent variations are probably real, and do not depend simply on distance of the cloud from the Galactic Center, as might be expected if interstellar clouds at a given distance are intermingled. The $^{17}O/^{18}O$ abundance ratio is slightly greater in interstellar clouds than on Earth. Both deuterium and ^{15}N are substantially depleted in the Sagittarius clouds as compared with most other parts of the Galaxy. This provides some

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evidence that deuterium in the Galaxy is a relict of events other than stellar activity.

Most of these results fit rather well current views of the nucleosynthesis and evolving stellar history of the Galaxy. However, the variation in isotopic ratios seems to show that the large molecular clouds, of mass $10^5 - 10^6$ $M_\odot$, retain their integrity for approximately 10^9 years or longer, i.e. comparable with the galactic lifetime. The Earth may have been formed in a cloud which was somewhat poorer than average in ^{13}C relative to ^{12}C. The long lifetime of massive clouds is not surprising except in view of possible gravitational collapse, for which important details of the dynamics involved are obscure.

Discussion Van den Bout: Comparison of 2-cm absorption and 2-mm emission by H_2CO gives a higher $^{12}C/^{13}C$ ratio than do other molecular lines - Townes: The discrepancy may not be real. - Watson: The 3757 Å line of CH^+ in ζ Oph gives a terrestrial $^{12}C/^{13}C$ ratio - Townes: The optical observations are restricted to tenuous rather than dark clouds; this may make a difference in the abundance ratios.

THEORY OF INTERSTELLAR CLOUDS AND THE FORMATION AND EXCITATION OF MOLECULAR HYDROGEN, A. Dalgarno.

The observational data from the Copernicus satellite on the relative abundances of atomic and molecular hydrogen are generally consistent with a theory that postulates an equilibrium between formation of H_2 on grain surfaces and destruction by fluorescent dissociation induced by the interstellar radiation field.

H_2 is detected in excited rotational levels. The rotational populations can be explained by a combination of ultraviolet pumping and excitation during the formation process. Application of the theory requires the solution of the vibratrional-rotational radiative cascading problem. Cascade tables have been constructed and used to infer the densities, the temperatures and the ultraviolet radiation-field intensities for several clouds. The derived densities range from 10 to 1000 cm^{-3} and the gas pressures from 10^3 to well over 10^4 cm^{-3} K; there is little evidence for a uniform cloud pressure supported by an intercloud medium. In some of the clouds the derived radiation field is unusually large, suggesting that the cloud is close to the parent star and presumably physically associated with it.

There is also clear observational evidence for clouds that are sheets 0.01 pc thick with densities between 100 cm^{-3} and 1000 cm^{-3}, produced presumably by shock waves assosiated with expanding HII regions or old supernova remnants. Stellar winds of early-type stars may also produce thin, dense circumstellar shells which will contain rotationally excited H_2.

The Copernicus data also reveal the presence of HD in amounts which show that there must be a source of HD in addition to grain formation, which is probably the reaction sequence $H^+ + D \rightarrow H + D^+$, $D^+ + H_2 \rightarrow H^+ + HD$. From the measured abundance of HD, the proton density can be derived and from it the ionizing flux within the cloud. Ionizing fluxes ranging from 10^{-17} to 10^{-15} sec^{-1} for different clouds have been derived. Although the variation in the fluxes is probably real, the estimates are sensitive to the adopted models. Ionizing fluxes can also be derived from the *observed abundances of OH. For ζ Oph the value is 1.6 x* 10^{-17} sec^{-1} *which, if correct,* excludes the possibility of low-energy cosmic-ray ionization in the cloud.

Emission lines of the 1-0 band of H_2 have been detected recently in Orion and in NGC 7027. Emission from higher vibrational levels was not detected and the origin of the excitation is uncertain. Whether it is ultraviolet pumping or collision excitation, densities of order at least 10^6 cm^{-3} appear to be required.

Controversy persists over the heating due to the grain photoelectric effect, but it seems likely that it is the major source in diffuse clouds. Other sources are cosmic rays, H_2 photo-dissociation, and possibly H_2 formation. If H_2 formation is a heat source, hydrogen atom recombination during cloud collapse may significantly affect the thermal structure of the cloud. The hydrogen atoms are assumed to exist in excess of their equilibrium abundance, because in the evolution of a dense cloud the time scale for molecular-hydrogen formation may be long compared to the cloud lifetime.

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Cooling is affected by the formation of molecules, which may generate instabilities leading to fragmentation and to the onset of gravitational collapse. Radiative trapping tends to suppress the instability.

FORMATION OF INTERSTELLAR MOLECULES, W.D. Watson.

Recent and forthcoming reviews of this topic include those by Dalgarno and Black (Rep. Prog. Phys., in press), Herbst and Klemperer (Phys. Today 29, 32), and Watson (Rev. Mod. Phys., Oct 1976).

Until about 1973, formation of most interstellar molecules was thought to occur on surfaces of interstellar grains. Neither a precise understanding of the relevant processes, nor clear predictions that can be tested, are available due to the uncertainties in the surface physics. Consideration of reactions between positive ions and molecules, which began in 1973, has shown that many small interstellar molecules can be produced readily by gas phase reactions. For some molecules (e.g. HD, CH^+, HCO^+, DCO^+, N_2H^+, CCH, HNC) this may be the only adequate process. The key to achieving adequate ionization rates is the efficient transfer of ionization of hydrogen and helium by cosmic rays to less abundant elements. In dense interstellar clouds, HCO^+ is a "cornerstone" of the ion-molecule scheme. Its unambiguous identification with the X-ogen line during the last year provides strong support for ion-molecule reactions in interstellar clouds.

The production of OH and H_2O begins with $O + H^+ \rightarrow O^+ + H$, for which the cross-section is uncertain, and continues via OH^+ and H_3O^+. Initial detections of OH in diffuse clouds during the past year at wavelengths near 3080 A and 1220 A are in excellent agreement with abundance predictions based on these reactions.

Reactions on grain surfaces should produce OH and NH at roughly the same rate, except for the difference in the abundances of oxygen and nitrogen. The improved upper limit (NH/OH) < 1/100 obtained this year toward Omicron Persei is inconsistent with formation on grain surfaces having the expected properties.

In dense clouds, the ionization of H_2 and He by cosmic rays initiates the ion-molecule reactions. H_2^+ reacts immediately to produce H_3^+ ($H_2^+ + H_2 \rightarrow H_3^+ + H$), of which most probably leads to HCO^+ and N_2H^+ in collisions with CO and N_2. At higher densities, the reaction $CO + N_2H^+ \rightarrow HCO^+ + N_2$ preferentially depletes N_2H^+. This phenomenon apparently is observed in maps of N_2H^+, HCO^+ and SO_2 across the Orion Nebula. The observed variation is interpreted to indicate an upper limit for water, $[H_2O]/[CO] \gtrsim 1/6$.

Ionized helium is perhaps more important than hydrogen in the ion-molecule scheme. The reaction of He^+ with H and H_2 is extremely slow, so that most He^+ is used to produce reactive atoms and ions: $He^+ + (CO, N_2, \ldots) \rightarrow He + (C^+ + O, N^+ + N, \ldots)$. The ions react with molecular hydrogen and the atoms with H_3^+ to produce hydrides (e.g. H_2O, NH_3(?), CH_2). Charge-exchange with metal atoms may be significant for the neutralization of ions.

Quantitative predictions can also be made for certain small molecules containing more than one "heavy" atom. The most direct process for producing HCN predicts $[HCN/NH_3] < 0.6$, a result only marginally consistent with observation. Unambiguous identification of the HNC microwave line which is comparable in strength to that of HCN is especially interesting for studies of reactions. A gas-phase formation is strongly indicated. Despite its wide occurrence, even in relatively diffuse regions, formaldehyde's formation is still a problem. CCH is also expected to occur widely - a prediction that has been verified by observation. Specific formation schemes in the gas phase for more complex molecules are not available.

The discussion centred on the importance of activation energies in ion-molecule reactions.

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THE NATURE OF DUST GRAINS, P.G. Martin.

The formation and destruction of grains, dust in HII regions and molecule formation are omitted.

The gas-to-dust ratio is 100, from 21-cm, X-ray and Lyman-α observations, consistent with cosmic abundances and gas depletion. R is 3.3, with variable-extinction and colour-difference methods agreeing, even in Orion. Dust changes from place to place are nevertheless seen in variations of ultraviolet extinction, of λ_{max} and λ_c, and of the ratio of ice (3.1μ) to silicate (10μ) extinction.

The albedo and phase function (g) are used in diverse problems, yet are still not well known. Brightness profiles of dark nebulae might give g. Interstellar circular polarization is consistent with an albedo ~ 0.7. The UV region is uncertain.

A pinwheel hypothesis is proposed to achieve grain alignment in a weak field. The 10μ polarization shows silicates can be aligned. UV polarization measurements at the 2200 Å feature are needed.

Much laboratory work has yielded optical constants of silicates, carbonates and sulphates needed for IR identification. Normal rocks have too high an intrinsic band strength to explain the 10μ polarization spectrum. The graphite interpretation of 2200 Å absorption is not firm.

Diffuse bands are well-correlated with eachother. The lack of a λ 4430 blue emission wing and of polarization structure at λλ 4430, 5780, 6284 rules out a normal-sized grain explanation; the λ 5780 asymmetry is consistent with small (unaligned) grains. Lab work has also eliminated the H^-, C^- or O^- alternatives.

Electromagnetic scattering by spheroids or even 'bricks' can now be computed.

Temperature fluctuations of small grains, important for mantle accretion and molecule formation, are discussed.

The study of far-infrared (100μ-1mm) thermal emission from grains represents a new frontier.

<u>Discussion</u> Isobe: The ratio R of total to selective extinction is longitude-dependent. - R.W. Wilson: Both $A_V/E(B-V)$ and the ratio of ultraviolet and visual extinction are strongly variable.

<u>Contributed paper:</u> Ultraviolet extinction observations by ANS in ρ Ophiuchi and Orion, by D.P. Gilra.

<u>Session 4/5: Interstellar Matter in External Galaxies</u>

Joint Meeting of Commissions 34 and 28; 26 August 1976
Chairmen: H. van Woerden and E.B. Holmberg;
Secretaries: W.B. Burton and M. Peimbert.

H II STUDIES OF LOCAL-GROUP GALAXIES, G. Courtès.

The galaxies of the Local Group showing H II regions have the great advantage of being close enough to provide, sometimes more easily than in our Galaxy: the fine morphology and distribution of those H II regions; their unambiguous positions compared with those of stars and H I contours; the precise shape of spiral patterns and their true galactocentric distances.

Recent observations using high-sensitivity monochromatic detection and new optical designs have given very efficient means for understanding of galactic and extragalactic structures.

Efforts have been made to obtain standard sizes of H II regions, in order to resolve extragalactic distance-scale problems.

Studies of star formation at the front of spiral features rich in H II regions have been discussed in relation with the kinematics of the gas as well as with stellar distribution and evolution.

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Several new kinds of H II regions have been distinguished, up to the very extended diffuse emissions of spiral arms, disk and central regions.

Results from high-sensitivity and high-resolution spectrography, and from far-UV space astronomy, give a first general explanation of the different modes of excitation of these emission phenomena.

Discussion Pecker: In M31 and M33 the sizes of H II regions are well-defined functions of galactocentric radius R; hence they can be used as distance indicators. - Courtès: In fact, the sizes are similar in M31 and M33.- De Vaucouleurs: The range of sizes of H II regions is much smaller than that of galaxies.- Van den Bergh: Why do the shapes of H II regions in M33 vary with R, with ring shapes in the outer parts? - Courtès: I don't know.

INTERSTELLAR ABUNDANCES IN EXTERNAL GALAXIES, B. Louise Webster.

It is now well established that the relation between the ionization level of an H II region and its galactocentric distance which was seen in some spiral galaxies by Aller and then by Searle, is a consequence of a gradient in the abundances of oxygen and nitrogen relative to hydrogen. Searle's original interpretation has been confirmed by further model computations and by detailed observations of the emission-line intensities, especially those giving the electron temperatures. There is also an indication of a second effect, a variation in the energy distribution of the radiation ionizing the H II regions with galactocentric distance. It has been suggested that the maximum mass that may form a star depends on the heavy-element abundance and that massive hot stars cannot form in the metal-rich, inner regions of galaxies. Alternatively, it has been proposed that more dust grains modify the radiation field by preferentially absorbing the higher-frequency photons.

Work is going on at present to apply these interpretations of H II regions to the wider problem of evolution within different types of external galaxies. There is a close relation between the morphological type of a galaxy and the excitation properties of its H II regions. The trend is from generally low excitations in Sbc supergiant galaxies, through strong gradients in later-type spirals and giant galaxies, higher excitation and lower abundances with no gradients in LMC-like galaxies, to very low abundances in dwarf and very-low-surface-brightness systems.

THE HELIUM PROBLEM, M. Peimbert.

(a) Our Galaxy and the Magellanic Clouds

Observations of H II regions and planetary nebulae suggest that the pregalactic helium to hydrogen abundance ratio is $N(He)/N(H) = 0.074 \pm 0.006$. There is no observational evidence for a smaller pregalactic ratio. Infrared and radio observations of the galactic center indicate that $N(He^+)/N(H^+) = 0.085$ and that $N(He)/N(H)$ could very well be twice as high. The pregalactic helium abundance can be used to determine the increase of the helium abundance by mass, ΔY, for different objects in our Galaxy, to choose appropriate models of stellar evolution for metal-poor objects, and to derive accurate ages for metal poor globular clusters.

A ratio of helium to heavy-element enrichment by mass of $\Delta Y/\Delta Z \sim 3 \pm 1$ has been found from observations of H II regions and planetary nebulae. This ratio is larger by at least a factor five than the one predicted by standard models of stellar evolution. Possible solutions to this discrepancy are mentioned.

In the interstellar medium of the solar neighbourhood it has been found that $\Delta Y + \Delta Z \sim 0.1$. This value can be used to estimate the total energy emitted by the Galaxy in its lifetime.

(b) Cosmology

Observations indicate that the pregalactic helium abundance derived from our Galaxy and the Magellanic Clouds holds for objects as distant as 100 Mpc. Moreover the most recent results from quasars are not in contradiction with this value. Therefore it seems that there is a general process which is responsible for a pregalactic production of N(He)/N(H) ~ 0.07.

This pregalactic helium abundance coupled with the standard big-bang model implies an open Universe. A similar result is derived from the deuterium abundance. Under the adoption of a big-bang model with nonzero lepton numbers the pregalactic Y value provides us with a restriction on the model which is independent of the deuterium restriction.

Discussion of reviews by Webster and Peimbert Mrs. Collin emphasized the difficulties in deriving the O/N ratio from certain lines. - Pecker: Heavy elements may be expelled from the Galaxy while helium is retained. This would invalidate Peimbert's assumptions in the derivation of $\Delta Y/\Delta Z$. - Anonymous: Nitrogen may be a factor four underabundant in the LMC compared to the solar vicinity; or the solar oxygen abundance may be overestimated. - Peimbert: The comparison Magellanic Clouds - solar neighbourhood is based on several H II regions, not on the Sun alone.

WARPED HYDROGEN DISKS IN GALAXIES, R. Sancisi.

Observations of nearby edge-on galaxies in the 21-cm hydrogen line with the Westerbork Synthesis Radio Telescope have revealed a significant bending of the outer gas layer in four out of five systems. Three of these systems (NGC 5907, 4565 and 4244) are fairly isolated in the sky. The most pronounced and unambiguous warp is found in NGC 5907, where the deviation of the HI layer from the optical plane is about 20 percent of the radius. NGC 4565 and 4244 have a smaller distortion. NGC 4631 has a large warp but also a close and disturbed companion, NGC 4656. NGC 891 has neither.

The origin and survival of these warps are not understood. Tidal explanations do not seem to be adequate in at least three cases.

Discussion M.A. Gordon: Can you say where the inflection originates? - Sancisi: Usually at the edge of the optical image. - Field: If the point of inflection were on the line of sight to the main body of the galaxy you would not notice it. - Verschuur: Several years ago I suggested that the high-velocity clouds might be explained by a warp in our Galaxy. - M.S. Roberts: Very deep plates of M31 by Arp and Wilson show that this galaxy looks like an integral sign as does NGC 5907.

WARPED HYDROGEN LAYERS: THEORY, Alar Toomre.

The warped neutral-hydrogen layers of the seemingly isolated edge-on spirals NGC 5907 and 4565 just reported by Sancisi constitute a fascinating dynamical puzzle, exactly as he said. To this theorist, who with Hunter (1969, Ap.J., 155, 747) concluded that such integral-sign shapes could not long endure, they are indeed a source of embarrassment: Unlike the warps of our Galaxy or those of NGC 3190 and 3628, they cannot even hypothetically be attributed to any visible companions - nor, unlike with the already serious analogous claims made for M31, M33 and M83, can one remotely claim these data to be geometrically ambiguous.

This talk contained no new answers. It mostly just reviewed such past work as the recognition already by Kahn and Woltjer (1959, Ap.J., 130, 705) that bent shapes are very prone to distort and ultimately destroy themselves via differential precession, or the couterclaim by Lynden-Bell (1965, M.N., 129, 299) that at least in highly-flattened Maclaurin spheroids and some closely related (if perhaps artificial) models one can find genuine modes of bending which precess indefinitely without any deformation. It also touched on the pros and cons of Kahn and Woltjer's old suggestion of distortion due to intergalactic winds, and the suggestion by Rogstad et al. (1976, Ap.J., 204, 703) that the blame might instead lie in some fairly recent but massive infall of gas into those galaxies. Most likely, this reviewer feels, Hunter and Toomre were simply mistaken in concluding that long-lived, discrete modes of bending are impossible in realistic disks - but he certainly remains at a loss to know just where or why such a mistake may have occurred.

Discussion Mrs. Pismis: Attempts at interpreting galactic warps will depend on their assumed age: 10^9 or 10^{10} years? - Oort: The external material may still be reminiscent of the conditions at the time of formation of the galaxy. - Toomre: A tilted halo is possible, but dynamical friction will make the material find the plane in a relatively short time. - De Vaucouleurs: In several galaxies tidal interaction must be responsible for distortions. Also observations are compatible with the idea that our Galaxy is tidally affected by the Large Magellanic Cloud. - Toomre: Tidal interaction is not dismissed, but the conditions for the warp in our Galaxy make a tidal interpretation very unlikely.

THE GAS CONTENT OF EARLY-TYPE GALAXIES, Hugo van Woerden.

The amount of gas present in elliptical (E) and lenticular (L, or SO) galaxies has been a matter of controversy for some time. While HI in ellipticals remained undetected despite persistent efforts, Balkowski et al. (1972, A & A 21, 303) found a gas fraction M_H/M_t in lenticulars similar to that in early spirals (Sa-Sb). However, Gallagher, Faber and Balick (1975, Ap.J. 202, 7) conclude that normal SO's are gas-poor and fit the general run of M_H/M_t (or M_H/L_B, where L_B = blue luminosity) with morphological type, although peculiar and interacting systems are often gas-rich. The lack of gas in E and SO galaxies is difficult to understand, unless the gas shed by evolving stars is removed by galactic winds or by intergalactic ram pressure.

Recent unpublished results have changed the picture considerably. Observations by Knapp, Faber and Gallagher at Green Bank, confirmed by Knapp and Kerr at Arecibo, give the first reliable detection of hydrogen in an elliptical: NGC 4278 has M_H = 7×10^8 $\odot$, or M_H/L_B = 0.05. Krumm and Salpeter at Arecibo, and Knapp et al. at Green Bank, have detected several SO's with M_H/L between 0.01 and 0.1. Van Woerden, Mebold, Goss, Siegman and Hawarden (1976, Proc. Astr. Soc. Australia, in press), having measured some fifty SO and SO/a galaxies at Parkes, find hydrogen in at least sixteen, with M_H/L_B ratios ranging from 0.1 to 2, a value high even for a magellanic irregular. Deep IIIa-J plates taken with the Siding Spring Schmidt lead to revised classifications for many galaxies. However, gas-richness clearly does not correlate with optical morphology: the highest M_H/L_B ratios occur in NGC 1512, a distorted SBO with faint tidal arms, interacting with a blue(!) EO; in NGC 6902, an SO/a with a bright lens surrounded by well-developed but faint spiral arms; and NGC 1533, a true lenticular. The cause of the great spread (a factor 100) in M_H/L among SO's remains unclear; and why are some gas-rich systems devoid of spiral structure?

Discussion Mrs. Faber: The detection of hydrogen in NGC 4278 is not in disagreement with previous upper limits. The new Parkes results suggest that southern SO's are richer in gas than northern ones. - De Vaucouleurs: Accurate galaxy types are required; the classifications of many southern galaxies are poor. - Van Woerden: However, no reclassification explains the high M_H/L_B ratios mentioned above.

Contributed Paper: Observations by ANS of dust in galaxies, by C.-C. Wu.

Session 6: New Results in Interstellar Physics

Meeting of Commission 34, held 27 August 1976.
Chairman: H. van Woerden.

The following contributed papers were presented:

The temperature distribution of neutral hydrogen at high galactic latitudes, by Y. Terzian.

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A Nançay H I absorption survey towards extragalactic radio sources, by J. Crovisier, I. Kazès and D. Aubry.

Molecular hydrogen in the Orion Nebula, by U. Fink.

CH spectra of Sgr B 2, by B. Andrew.

An experimental study of the 10μ band of cosmic dust, by C. Friedemann.

Spectral indices of background radiation between 38 and 408 MHz, by I. Milogradov-Turin.

Detection of S III (18.7μ) and O III (88.4μ) infrared-line emission from the Orion Nebula, by J.P. Baluteau.

Laboratory studies of Mg TBP and the diffuse interstellar lines, by F.M. Johnson.

Session 7/8: Interaction of Stars and Interstellar Medium

Meeting of Commission 34, held 28 August 1976.
Chairmen: G.S. Khromov and M. Peimbert; Secretary: H.M. Johnson.

COMPACT HII REGIONS, P.A. Shaver.

Most if not all compact HII regions have associated massive molecular clouds, observable at least in the lines of CO. These molecular clouds produce a great deal of visual extinction, so the optically visible HII regions must be on the near sides of the associated clouds, on the average. Recent studies of molecular and recombination lines show that the latter are significantly blue-shifted relative to the former on average, which is to be expected if the HII regions are comprised of ionized gas streaming away from the molecular clouds, and being replenished by them.

It is now known that HII regions emit almost all of their energy in the infrared. The 20μm/6cm flux ratio is particularly large for many of the smallest, most dense HII regions. An extreme case is the source Oph 4, a compact HII region in the Ophiuchus dark cloud; it is invisible, a weak radio and 2μm source surrounded by extended far-infrared radiation and carbon recombination-line emission, probably excited by an early B-star embedded in the dark cloud. Such radio and infrared studies of dark clouds appear very promising for the study of compact HII regions and early star formation.

The association of compact HII regions with maser sources is now well-established. 80 percent of Type-I OH masers coincide with compact HII regions within a few arcsec, and 20-50 percent of compact HII regions have associated Type-I OH-maser sources. H_2O sources are also frequently associated with these sources. However these maser sources do not appear to be associated with larger HII regions: the OH-maser phenomenon seems to disappear when the compact HII region has expanded to about 15000 A.U.

Radio recombination-line studies of compact HII regions have advanced recently with the use of large synthesis radio telescopes; it is possible now to study the velocities and physical properties of individual compact components of HII complexes. Another important development has been the discovery of extended carbon recombination-line regions in dark clouds such as that in Ophiuchus; these probably indicate the presence of embedded early B-stars, and open a new window on star formation.

A tentative evolutionary scheme for HII regions is beginning to emerge. Initially the HII regions are extremely compact and dense, optically obscured, and have a large near-infrared flux and associated OH/H_2O maser sources. As they evolve, the maser phenomenon disappears and the HII regions become visible with decreasing reddening and near-infrared flux. Old HII regions eventually melt together into a diffuse complex, the infrared flux is comparatively weak, and the associated molecular cloud may have disappeared altogether.

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DUST IN HII REGIONS, Syuzo Isobe.

There is much direct and indirect evidence for dust in HII regions: (1) The continuum light scattered by dust grains (O'Dell and Hubbard 1965, Ap.J. 142, 591), (2) Thermal radiation from dust grains at infrared wavelengths (Ney and Allen 1969, Ap.J. 155, L193), (3) Abnormal values of $R \equiv A_V/E(B-V)$ in the direction of some HII regions, (4) The three-micron and ten-micron absorption features (Gillett and Forrest 1973, Ap.J. 179, 483), (5) Abnormal helium abundance in some HII regions (Peimbert and Castero 1969, Bol. Obs. Tonantzintla 5, 3), and so on.

O'Dell et al. have found dust deficient in the inner parts of HII regions, especially of the Orion Nebula, but rather overabundant in the outer parts. Consideration of the effect of an isotopic scattering by dust grains changes these conclusions.

Münch and Persson (1971, Ap.J. 165, 241) found that dust is well mixed with gas in the Orion Nebula. The similarity of intensity distributions of hydrogen recombination lines and infrared radiation appears to confirm this. However, calculation of the expected infrared radiation indicates dust depletion by a factor 10 to 100 (Harper et al. 1976, Ap.J. 205, 136).

Graphite and silicate grains are stable even in HII regions, but will be blown out from the central parts (< 0.1 pc) by radiation pressure. On the other hand, gas expansion from adjacent molecular clouds will supply dust to HII regions.

Churchwell et al. (1974, A & A 32, 283) find from radio recombination lines that only three out of 39 HII regions have abnormally low helium abundances. Since the main cause of the observed helium deficiency in HII regions is the destruction of helium-ionizing photons by dust grains (Mezger et al. 1974), there must be few dust grains in many HII regions. Although radio data indicate a normal helium abundance in the Orion Nebula, optical data show depletion of helium in the central region (Peimbert and Castero 1969).

These contradictions are resolved by consideration of the globule model proposed by Dopita et al. (1975, Ap. Space Sci. 34, 91). Optical observations are weighted to the high-density region, where dust grains just ejected from globules destruct the helium-ionizing photon; by the radio technique we look through the dust-free regions.

From a statistical analysis of intensity fluctuations in the central region of the Orion Nebula Tamura (1976, Sci. Report Tohoku Univ.) finds a total number of 400 condensations and sizes of order 0.001 pc, consistent with earlier results of Dyson.

We conclude that the observations summarized in this review can be explained by introducing globules with dust envelopes in the HII regions.

UNUSUAL MOTIONS IN HII REGIONS, John Meaburn.

One of the most interesting, and still unexplained, phenomena associated with HII regions are the huge volumes of ionized gas emitting split lines. Large-scale line splitting has been found by Wilson, Münch, Flather and Coffeen (1959) in M42, by Deharveng and Maucherat in the Orion and Carina Nebulae, by Smith in the Rosette, and by Meaburn and collaborators in M42, M16, M8, M17 and NGC 2264.

In M42, the linear scale of this type of splitting increases from the dense (10^4 to 10^3 e/cm^3) core to the outer regions. Moreover, all the split regions in this nebula have been shown (by Elliott and Meaburn and Dopita, Isobe and Meaburn) to be over the dark areas surrounded by bright rims produced by ionization fronts eating into the adjacent neutral masses.

In M16, M17, M8 and the Doradus Nebula the nebular lines are doubled to both negative and positive velocities (a) with respect to their positions when bright and single and (b) with respect to the mean motion of the adjacent neutral masses of HI and molecules, out of which the nebulae are forming. In these nebulae the splitting again occurs, exclusively, over the obvious dark neutral intrusions, away from their surrounding bright rims; over these rims the bright nebular lines are always single. In M17 up to five components appear in several adjacent fields. Most curious, though, is the apparent association in this nebula of the splitting in the [OIII] and CO lines.

In the Large Magellanic Cloud, the blue supergiants and HII regions appear to delineate a spiral galaxy, with the Doradus Nebula as its nucleus. In this nebula the huge volume (50 pc size), surrounded by bright rims, which is emitting split lines also contains a massive group of young stars. The H and K absorption lines in their spectra, as measured by Feast, are centred on the most positive velocity component of the doubled nebular line. We suggest that this may imply a state of implosion: a neutral shell of 50 pc diameter, with an ionization front on its inner boundary, could be falling in towards the ionizing stars.

The high velocity dispersions, > 100 km/s (not splitting), found in small ($\lesssim$ 0.1 pc), dense (10^4 to 10^5 e/cm^3) ionized and neutral concentrations (Herbig-Haro objects?) are distinctly separate phenomena. These motions have been found by Gull (échelle spectrograph), by Münch and Taylor (two-etalon Fabry-Pérot), and by Glushkov and his associates (conventional grating spectrograph) in a variety of HII regions.

Discussion The interpretation of velocities in photographic interferograms is difficult in the presence of discontinuities of background brightness. - T. Wilson: I question the assumptions of spatial symmetry in the 30 Dor region.

Contributed paper: High-velocity structures in the Orion Nebula, by T.R. Gull.

PLANETARY NEBULAE, G.S. Khromov.

While the theory of the radiation of planetary nebulae (PN) appears satisfactory, the quality of observations often leaves much to be desired. Even in close doublets, relative line intensities may be seriously in error, probably owing to erroneous estimates of the continuum. These errors affect the determinations of electron density.

The radio and optical images of PN are much alike. More surprises may come from emission in the 21-cm and molecular lines.

Infrared observations suggest that dust is well mixed with the gas; in the younger planetaries the dust may be hotter and the infrared emission is stronger.

Determinations of the physical parameters of PN are hampered by incomplete and unreliable spectrophotometric data, and by structural peculiarities. Computer models have so far been too primitive. Both density and ionization must vary with radius, and are interdependent; hence, shell models are required.

Studies of small-scale condensations have centred on the comet-like structures in NGC 7293. The physical conditions there are probably close to those in the main body of this nebula, but spectra must resolve this matter.

Since the publication of the Perek-Kohoutek Catalogue, few misidentifications and new discoveries have been reported; we may actually know most of the galactic planetary nebulae. Shklovskij's method of relative distance determination, based on visible disks, appears reliable but absolute calibration remains a problem.

The evolution of PN shells is observed over 4 or 5 orders of magnitude in density. However, densities above 10^8 cm^{-3} are not observed and the evolution of PN progenitors (out of old red giants?) remains speculative. Age estimates based on a constant rate of expansion are clearly too primitive. The increase of the ratio of the HeII λ 4686 to Hβ with time does not necessarily imply an evolutionary rise in temperature of the PN nucleus.

Discussion Peimbert: The scale of the comet tails in NGC 7293 is 10^{16} cm. - Anonymous: While in NGC 7027 the infrared and HII maps agree, in other PN the IR region is the smaller. - Seaton: In NGC 7027, hot and cool dust have quite different distributions.

Contributed papers: Rocket-UV spectra of planetary and diffuse nebulae, by T.P. Stecher. Binary nuclei in planetary nebulae, by Mrs. A. Acker.

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CIRCUMSTELLAR MASERS, Lewis E. Snyder.

OH, H_2O and SiO are the molecules found in maser emission from circumstellar shells. SiO is the newest circumstellar maser. The SiO maser has small source size, shows some evidence for circular polarization, has time-varying intensities and nonthermal populations. Several pumping theories have been developed to explain the nonthermal populations and observed SiO intensities.

At present there are 42 known SiO maser sources. Ori A is the only SiO maser source which is also associated with a molecular-cloud region. Most of the other SiO sources readily can be associated with known late-type stars.

Van Blerkom and Auer noted that the high excitation energies required for SiO require the inversion to occur close to the stellar photosphere (perhaps within a few stellar radii), while the OH maser is formed in a region more than 100 stellar radii distant. Their solution of the SiO radiative transfer problem for a spherical shell gives an asymmetric emission doublet; for a rotating disk, it is an emission triplet. The distinctive triplet structure in the velocity pattern of the SiO maser lines observed in both VY CMa and NML Cyg suggests that these stars may be young objects still surrounded by "solar nebulae"; this conclusion supports Herbig's model for VY CMa.

Reid and Dickinson have used ground-vibrational state SiO data to argue quite convincingly that the true stellar velocity of long-period variable stars is not given by the optical absorption lines but instead lies between the optical absorption and emission lines near the midpoint of the OH radial velocity pattern.

The SiO emission in Orion has the doublet structure typical of the spherical shell surrounding a late-type star; the velocities match that of the H_2O maser emission. Results of a recent VLBI observation show the strongest SiO maser source in Orion to be greater than 4 A.U., which is consistent with the size of the corresponding H_2O feature.

There is a high degree of correlation, perhaps 80% or more, between OH, H_2O and SiO circumstellar maser stars. The failure to detect SiO masers in known OH/H_2O/IR sources associated with HII regions and molecular cloud regions (other than Orion) could be due to beam dilution and/or phase effects. If not, the absence of SiO maser emission would serve as an observational indication that particular OH/H_2O/IR sources are not associated with late-type stars and hence may be much younger, protostellar regions.

Discussion Buscombe: Have the searches for SiO masers been limited to known OH and H_2O sources, or extended to lists of other cool red giants with extended atmospheres, especially semi-regular and long-period variables? In my Third General Catalogue of MK Spectral Classifications (soon to appear) are hundreds of such stars, with positions for epoch 2000 and some UBV photometry at maximum light.

Contributed paper: Circumstellar CO and HCN, by B. Zuckerman.

Session 9: Large-Scale Distribution of Interstellar Material

Joint Meeting of Commissions 33 and 34, held 30 August 1976.
Chairman: F.J. Kerr.

This session is reported by Commission 33.

Session 10/11: Non-Circular Motions in the Galaxy

Joint Meeting of Commissions 33 and 34, held 31 August 1976.
Chairmen: H. van Woerden and L. Perek.

This session is reported by Commission 33.

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COMMISSION 35: STELLAR CONSTITUTION (CONSTITUTION DES ETOILES)

Report of Meetings, 25, 26 and 27 August 1976

PRESIDENT: L. Mestel SECRETARY: R. C. Smith

27 August 1976

BUSINESS MEETING

The following nominations were approved.

PRESIDENT: B. Paczynski (Astronomical Observatory, Warsaw)

VICE-PRESIDENT: R. J. Tayler (Astronomy Centre, University of Sussex)

ORGANIZING COMMITTEE: D. J. Faulkner, P. Giannone, C. Hayashi, I. Iben, R. Kippenhahn, A. G. Massevich, G. Ruben, J.-P. Zahn.

Thirty-three new Commission members were elected. The Commission Report was formally adopted. It was agreed that the Report should continue to review in depth a limited number of topics rather than attempt to cover the whole field. It is hoped that with the new format agreed with the publishers, reprints of the next Report will be available before the next General Assembly.

25 August 1976

SOLAR AND STELLAR MAGNETISM
(Joint Meeting with Commissions 10 and 12; Chairman Professor T. G. Cowling)

1. Observations of Stellar Magnetism (Dr W. K. Bonsack)

This review concerns itself only with observations of effects in circularly polarized light which can be interpreted as the Zeeman effect. It is emphasized that the numerical values obtained for stellar magnetic fields depend strongly on the technique used. The classical photographic method assumes that the wavelength difference between line components in the two states of circular polarization can be interpreted as the Zeeman shift due to the component of the field along the line of sight (effective field), but this interpretation neglects such effects as incipient resolution of the individual Zeeman components and saturation in the line profiles. In addition, different lines, and different parts of the individual line profiles, are formed at different depths, and the depth-dependence of the field is not known. Individual line shifts are small, and are strongly affected by photographic grain. At least 25 lines per plate must be measured for reliable results, and numerical agreement between photographic results and photoelectric measurements depending on a single line should not be expected.

Among the magnetic A- and B-type stars, the largest field observed is still the 34-kG (surface) field found by Babcock in HD 215441. Resolved or partially resolved Zeeman patterns have permitted measurement of the total surface field in a few other stars (G.W. Preston, Ap.J. 164, 309, 1971) yielding values up to 17 kG. Interpretation of resolved and unresolved patterns has permitted derivation of the magnetic field geometry for β CrB (S. and R. Wolff, Ap.J. 160, 1049, 1970) and for 53 Cam (J. Huchra, Ap.J. 174, 435, 1972); in both cases a dipole field offset from the centre of the star represented the data reasonably well. The hottest known main-sequence magnetic star is the Bp helium variable HR 7129, in which R. and S. Wolff (Ap.J. 203, 171, 1976) found an effective field varying between +7 and -5kG; the effective temperature is near 20000 K. At the other extreme is HD 101065 (Przybylski's star), which has a constant field of +2 kG (S. Wolff and W. Hagen Pub.A.S.P. 88, 119, 1976) and probably has the temperature of an early F-type star.

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The majority of the magnetic stars which have been investigated in sufficient detail have been found to be periodic, including Babcock's prototype irregular variable, 78 Vir (G. W. Preston, Ap.J. 158, 243, 1969). Well established periods exist as short as three days. The upper limit to the periods cannot be easily established, but a monotonic field variation in γ Equ was interpreted as a part of a periodic variation of possibly 75 years duration by W. Bonsack and C. Pilachowski (Ap.J. 190, 327, 1974). Photoelectric observations (J. Landstreet, et al. Ap.J. 201, 624, 1975) indicated that fields in excess of 1 kG do not occur in stars with rotation periods shorter than approximately three days. There is no evidence that the character of the magnetic variation, or of the accompanying spectrum and light variations, change with period in the observed range; this suggests that the period is the rotation period in all cases. It remains possible that aperiodic phenomena do occur in these stars; sometimes these are superimposed on periodic effects (e.g. HR 2727, W. Bonsack, Ap.J. 1976, in press), and in other cases there may in fact be no discernable periods.

In summary, in the upper main sequence, magnetic fields are found in Ap stars of the Si and Cr-Eu-Sr types, providing that they rotate sufficiently slowly, and in at least some helium-variable Bp stars. Fields do not occur in Mn-Hg type Ap stars, Am stars, or normal A and B stars.

Magnetism in white dwarfs was detected by means of broad band polarization in the continuum in the DC (continuous spectrum) star Grw+70°8247 by J. Kemp et al. (Ap.J. 161, L77, 1970) following the theoretical prediction of the effect by Kemp (Ap.J. 162, 169, 1970). The measurements were interpreted as representing a field of 1×10^7 gauss. Several additional magnetic DC white dwarfs have since been found. Attempts to detect the (quadratic) Zeeman effect in the hydrogen lines of DA stars yielded only an upper limit of 5×10^4 gauss (J. Elias and J. Greenstein, Pub.A.S.P. 86, 957, 1974; J. Angel and J. Landstreet, Ap.J. 160, L147, 1970) until Angel, et al. (Ap.J. 194, L47, 1974) recognized resolved patterns of the quadratic Zeeman effect in the Balmer lines of GD90. The data were interpreted in terms of a field of 1×10^7 gauss. The systematics of white dwarf magnetic fields are unclear, except that the fields are quite rare, and usually constant in time.

In the discussion, Dr A. Severny, summarizing observational work in the USSR, claimed that their photoelectric method measured essentially the longitudinal component of the field, whereas the photographic method mainly used in the US measures the total field; but Dr Bonsack argued that this is an oversimplification. Dr Severny reported on the occasional appearance of weak fields in bright stars such as Vega and Sirius A; and of fields of several hundreds of gauss in two Am-stars.

2. The Solar Magnetic Field - Observation and Theory (Dr N. O. Weiss)

Both observations and theory were recently discussed at IAU Symposium No.71 (Basic Mechnisms of Solar Activity, ed. Bumba and Kleczek; see especially the review by Stix). The basic features of the solar cycle are well known: the 11 year sunspot cycle is really a 22 year magnetic cycle, dominated by strong toroidal fields, of opposite sign in the two hemispheres, whose development is summarised in the butterfly diagram. Other stars with convective envelopes show similar behaviour, as measured by variations in Ca K emission. So the sun should be regarded as a model, unique in that we can observe its field in some detail. Magnetograph measurements show active regions and weaker, irregular polar fields. The latter reverse around sunspot maximum but they behave erratically and there are periods when both poles show fields of the same sign.

Babcock's phenomenological model of the solar cycle had flux ropes which were drawn out by differential rotation. Leighton added turbulent diffusion, caused by supergranules, and, with plausible assumptions, reproduced the butterfly diagram

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and the correct period. Yoshimura (Ap.J.Supp. 29, 467, 1975) has recently obtained and solved the equations for a more elaborate model.

The same equations emerge from recent developments in kinematic dynamo theory. The theory of turbulent dynamos (mean field electrodynamics) has been developed principally by Krause, Rädler and Steenbeck, starting from Parker's concept of cyclonic eddies. The mean magnetic field $\underline{B}$ satisfies the equation

$$\frac{\partial \underline{B}}{\partial t} - \text{curl } (\underline{u}\times\underline{B}) = \text{curl } (\alpha\underline{B}) + \eta\nabla^2\underline{B},$$

where $\underline{u}$ is the velocity and η is the total (molecular and turbulent) diffusivity. The poloidal field is generated from the toroidal field through the "α-effect", and the parameter α depends on a lack of isotropy in the turbulence. More specifically, for turbulence that is not mirror-symmetric, α is proportional to the average value of $\underline{u}$.curl $\underline{u}$ (the helicity). A reversed toroidal field is then produced by differential rotation. Many oscillatory dynamo models have now been computed, reproducing the butterfly diagram with remarkable fidelity.

Despite this success, mean field dynamos have been criticized, especially by Piddington (see Cowling, Nature, 255, 189, 1975). The observed fields form discrete flux tubes instead of a turbulent mess; moreover, opposed fields can only be eliminated by invoking some dynamically driven reconnection process. The theory also depends on averaging over the smaller of two distinct scales, and on first order smoothing, neither of which is valid for the sun. Piddington has therefore revived the magnetic oscillator theory, while Layzer, Rosner & Doyle have proposed a hybrid model. Nevertheless, mean field dynamos are now generally accepted as reasonable illustrative models of the solar cycle, and emphasis has switched to the construction of nonlinear dynamos, including the effect of forces exerted by the magnetic field.

The next stage must be to relate dynamos to the hydrodynamics of convection in the sun. There are several scales of cellular convection, affected differently by rotation, and it is necessary to compute the resulting distributions of angular velocity and helicity. Flux ropes are formed and react back on the motion. There must be a balance between the tendency of convection to pump flux downwards and that of buoyant flux ropes to float upwards. Other problems which can probably be reconciled with dynamo theory are the erratic behaviour of the polar fields (which must be indicators, rather than essential features, of the dynamo process); the rigid rotation of the sector structure and coronal holes; and the remarkable secular variation of the solar cycle itself (Eddy, Science, 192, 1189, 1976). We now have a crude understanding of solar magnetic fields but proper, detailed models have yet to be constructed.

3. Stellar Dynamos (Dr W. Deinzer)

Turbulent $\alpha\omega$- and α^2-dynamos. Applying the theory of the turbulent dynamo (see P. H. Roberts and M. Stix, The Turbulent Dynamo, NCAR, 1971) to a differentially rotating star, an axisymmetric magnetic field

$$\underline{B} = (0,0,B) + \nabla\times(0,0,A)$$

is produced according to the equations

$$\frac{\partial B}{\partial t} - \eta\nabla^2 B = \hat{Q}_B(\omega,\alpha)A$$

$$\frac{\partial A}{\partial t} - \eta\nabla^2 A = \hat{Q}_A(\alpha)B$$

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Here η is the magnetic diffusivity, $\hat{Q}_A$ and $\hat{Q}_B$ are linear operators, ω is the angular velocity and α is a quantity describing (to lowest approximation) the inductive action of the turbulent medium. For vanishing α the dissipation of poloidal flux cannot be compensated and the dynamo breaks down. If the inductive action of the differential rotation is much stronger than the α-effect, the latter may be neglected in $\hat{Q}_B$ and the so-called $\alpha\omega$-dynamo is considered. If the matter is in solid-body-rotation $\hat{Q}_B$ as well as $\hat{Q}_A$ depend on α only and the so-called α^2-dynamo is working. A similar formalism can be set up if there is no axial symmetry.

Application to stars. (a) Fully convective stars in the Hayashi-phase. No convective envelopes as the seat of dynamos for an outer magnetic field seem to exist in magnetic stars. Hence even dynamo theory has to rely on "fossil" fields in this case, fossil in the sense that the fields were produced by a dynamo acting during the convective pre-main-sequence phase. An α^2-dynamo in fully convective stars is excited, if (P. H. Roberts, Phil.Trans.Roy.Soc. A 272, 663, 1972) $P_\alpha = |\alpha R/\eta| \gtrsim 8$. M. Schüssler (Astron.Astrophys. 38, 263, 1975) has shown that these fields survive when the stars evolve towards the main-sequence.

(b) Convective cores in main-sequence stars. Both types of dynamo have been applied. E. H. Levy and W. K. Rose (Astrophys.J. 193, 419, 1974) found excited $\alpha\omega$-dynamos for

$$P_{\alpha\omega} = P_\alpha \cdot \left| \frac{\Delta\omega . R^2}{\eta} \right| \gtrsim 10^3$$

$\Delta\omega$ is a measure for the variation of angular velocity due to differential rotation.

A. Pähler (Diplomarbeit, Göttingen 1976) found excited α^2-dynamos for $P_\alpha \gtrsim \pi$ (slightly smaller than the value found by F. Krause and M. Steenbeck, (Z.Naturforsch, 22a, 671, 1967), due to different boundary conditions). Obviously an α^2-dynamo is more easily excited in a convective core than in a convective envelope, because the field is enclosed completely in the finite volume of the core. The high electrical conductivity of the envelopes prevents the field from penetrating to the outside during the main-sequence life-time.

Excitation conditions. To find out whether the values requires for P_α and $P_{\alpha\omega}$ are feasible in the stellar context, formulae for α and η must be available. Using values presented by Krause (Habilitationsschrift, Jena, 1967),H. Köhler (Astron. Astrophys. 25, 467, 1973) was unable to reproduce the solar cycle; only after reducing α by three orders of magnitude a realistic solar cycle was obtained. Considering a random distribution of sound waves W. Deinzer (in preparation, 1976) found a value for α which in the limit of slow rotation is

$$|\alpha| = u^2 \frac{2\pi}{k} \frac{1}{\eta} \frac{\frac{\omega}{ck}}{1+(\frac{c}{\eta k})^2} \quad \text{for} \quad \frac{\omega}{ck} >> 1$$

(u velocity amplitude, c velocity of sound, k characteristic wave number). This formula gives for $\eta \sim u.\ell$ (the turbulent magnetic diffusivity) and $c >> \eta k$

$$|\alpha| \sim 2\pi \left(\frac{u}{c}\right)^3 \omega\ell = \left(\frac{u}{c}\right)^3 \alpha_{Krause}$$

which gives the reduced value required by Köhler, if $u \sim 1$ km/sec is assumed. Evaluating the dynamo number, $P_\alpha = 2\pi(u/c)^2(\omega R/c)$ is obtained. Assuming still $u \sim 1$ km/sec it is easily seen that only for low temperatures $T \lesssim 10^4$K, P_α is of order unity as required for excitation. Hence only the dynamo in the Hayashi-phase seems to be excited, whereas for dynamos possible in convective cores the production of magnetic flux is much smaller than the energy dissipated by Ohmic losses - at least if the inductive action of the turbulent medium is based on sound waves.

4. Stellar Magnetism - Theory (Dr L. Mestel)

Most of the points raised are summarised in Section 4 of the Commission 35 Report (Transactions Vol.A). Particular emphasis was laid on: (1) the distinction between a field maintained by contemporary dynamo action, and a slowly decaying "fossil" field, that may nevertheless be a relic of a field built up by dynamo action in an earlier phase of the star's life; (2) the necessity for a complete dynamo theory to include the dynamical back-reaction of the magnetic forces on the driving motions, as well as the condition that Ohmic flux destruction be balanced by kinematic flux replenishment; (3) the relevance of hydromagnetic stability theory in restricting the allowed field topologies; (4) the possible role of rotationally-driven circulation in explaining observed anti-correlation between surface field and rotation rate, and as a possible reason for the apparent preference for high angles of obliquity between rotation and magnetic axes.

26 August 1976

LARGE SCALE MOTIONS IN THE SOLAR ATMOSPHERE
(Joint Meeting of Commissions 10, 12 and 35; Chairman Dr M. Schwarzschild)

1. Recent Observations on Large Scale Solar Oscillations (Dr H. A. Hill)

In the fall of 1973 the observational program at SCLERA obtained its first evidence for whole-body oscillations of the sun. In the last several years considerable additional evidence for whole-body oscillations has been obtained by the group. At the present time, 20 modes have been identified with periods between 68 minutes and 6 minutes.

The statistical significance of the observed acoustic spectrum has often been questioned, and in some cases, claims have been made that the reported oscillations can be interpreted as noise. These analyses and conclusions, however, are considered inapplicable to the brightness measurements at SCLERA due to invalid statistical tests. A thorough treatment of the statistics shows that several tests strongly indicate that the reported observations are indeed statistically significant. The most striking evidence is that two modes remain coherent in phase over a duration of 40 days.

The brightness amplitudes of the oscillations observed at SCLERA are significantly larger than those inferred from either velocity or temperature measurements. The brightness and velocity amplitudes are in good agreement, however, after incorporating a proper theoretical treatment of acoustic wave propagation in the sun's outer layer. In fact, the resolution of this "paradox" has shown that the commonly used boundary conditions for pulsation theory in the sun are considerably in error.

With the incorporation of the acoustic wave theory, the temperature amplitudes inferred from the SCLERA measurements remain larger than those inferred using brightness changes in spectral lines. The theory used to interpret the spectral line observations, however, is applicable only for a non-oscillating system. It has been possible to show that the sensitivity of spectral lines to short-term temperature changes was in the past overestimated by an order of magnitude due to misapplication of static theory. This removes the above apparent temperature discrepancy and seriously impairs this technique in the study of small-amplitude oscillations.

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In summary, a very strong case can be made for the existence of whole-body oscillations in the sun. Much progress has also been made in understanding the physical processes leading to their detection. The observed normal mode spectrum is quite rich and should be possible to study in considerable detail.

2. Observations of the Line-of-Sight Velocity (Dr E. Fossat)

The sodium optical resonance device of the Nice group has been used by G.Grec and E.Fossat to measure the line-of-sight velocity averaged across the whole solar disk, with a sensitivity of about 1 ms^{-1}, for periods ranging between 5 and 90 minutes. The 5-min oscillation is clearly visible, with a r.m.s. amplitude of 2 ms^{-1}, but it is shown that the low frequency spectrum can be interpreted as pure atmospheric noise, due to fluctuations of inhomogeneous transparency in front of the rotating solar disk. A very simple atmospheric model can be deduced from the numerical results.

By comparison, an evaluation of what can be the atmospheric noise in the solar diameter measurements of the SCLERA group has been made. This noise comes from fluctuations in the differential refraction. A measurement of air-mass fluctuations has been made in Kitt Peak by E.Fossat and J.Harvey. With the only assumption that the same atmospheric model is still valid (because transparency and air-mass fluctuations are probably driven by the same physical processes, mainly convection), the noise induced by this result is exactly consistent with the quantitative SCLERA results. Furthermore, it is shown that the peaks in the SCLERA spectrum are consistent with statistical fluctuations around a continuous spectrum, which confirms the preceding interpretation.

It is concluded that up to now, no long period solar oscillation has been observed with periods between 5 and 90 minutes.

3. Observations of Oscillations of the Entire Sun (Drs V. Kotov, A.Severny and T. Tsap)

The existence of a stable 160^m period, previously found by Severny et al. (1976) has been confirmed by further observations during 1975 and 1976. We have also suspicions of the same periodicity in the solar luminosity and magnetic field.

The periodicities found near 147^m and 171^m are not definitely confirmed. It seems encouraging that periods found here ($\simeq 147^m$-149^m, 160^m, 171^m) coincide approximately with theoretical periods (147^m, 159^m, 171^m) of normal modes of the sun's vibrations found by Christensen-Dalsgaard and Gough (1976). The possible existence of oscillations with 147^m and 171^m periods in our data might indicate non-radial (ℓ=2) oscillations; if so, this is evidence in favour of the improved standard model of the solar interior, with a large abundance of heavy elements (Z=0.04). However, because the 147^m and 171^m periodicities, unlike the 160^m, are not persistent in phase, their nature is still not quite clear.

It would be premature to speculate about the physical nature, radial or non-radial, of either the 160^m or the less certain 147^m and 171^m oscillations, all of which may prove to be decisive for the solar interior problem.

4. Spatially Resolved Observations of Solar Global Relations (Dr F-L. Deubner)

Periods of solar pulsations found by Hill, Severny, and by Brookes and their collaborators were compiled in a frequency diagram and compared with the theoretically predicted frequencies of some low-order radial and non-radial global oscillations.

The comparison shows that unless the observations yield very high resolution in frequency and sufficient spatial resolution to distinguish between various modes with similar periods, it is impossible to deduce meaningful information about the solar interior from these low-frequency pulsations.

The brightness of Uranus and Neptune have been monitored with a double-beam photometer at ESO, La Silla. No periodic fluctuations of the solar luminosity in excess of 3 x 10^{-3} mag. have been detected in the low-frequency domain.

Spatially resolved observations obtained with a photoelectric lambdameter at the Capri observatory show low-frequency power equally distributed over a range of wavelengths from 25 Mm to about half the solar diameter, indistinguishable from convective motions.

On the other hand, the well resolved trapped acoustic modes of the 5-min oscillations appearing in the same data, present themselves as the most powerful tool presently available to probe the solar interior. The differences between the observed and the predicted modes should readily serve to improve the current models of the vertical structure of the solar convection zone as well as of the deeper layers which are affected by low-order non-radial globular pulsations.

The close coincidence of the predicted and observed non-radial f-modes seems to indicate that there is nothing basically wrong with the standard solar model.

5. CI 5380 as a Temperature Indicator and a Search for Global Oscillations (Dr W. Livingston)

The high excitation, weak Fraunhofer line CI 5380.3 Å is shown to originate within the same photospheric layers as the sun's continuous radiation. By monitoring the central depth of the CI line relative to the local continuum, in unfocussed sunlight, we may follow temperature, and hence luminosity changes of the whole sun as a function of time. The technique is practically insensitive to telluric absorption effects and instrumental spectral response. A power spectrum analysis of 100 hours of observations reveals no dominate oscillation of period P_h rising above the 3σ uncertainty limit of 0.4K for $5^m \leq P \leq 60^m$. For power at 2^h40^m the limit is 1.0K, for 5^h20^m, 2.0K. The day-to-day fluctuation for a three month period is 0.85K, rms (which corresponds to 0.06% in the solar constant, or 0.0006 mag. in luminosity.

6. Theory of Solar Oscillations (Dr D. O. Gough)

Whether the sun is simultaneously oscillating in many modes is not yet resolved. Professor Hill has presented a case which makes it look likely, but his arguments have not been widely accepted. To the eye, the averaged spectrum does show a qualitative discontinuity at about the acoustic cut-off frequency of the solar atmosphere, and I should emphasise that the eye provides a very sensitive, though occasionally unreliable, statistical test. Oscillations are presumably apparent in the raw data, since it was by visual inspection of the oblateness record that led Hill to the discovery. The most convincing evidence is perhaps the long term phase coherence, but we must await more thorough analysis before that is assured. The failure of Livingston, Milkey and Slaughter to observe oscillations in temperature does not contradict Hill's claim, because the sensitivity of their method to detect oscillations may be too low.

Fossat has pointed out that under certain statistical tests Hill's data is consistent with noise. Care must be taken when interpreting this remark, for it does not follow from this that Hill's data contains only noise. Moreover, what one means by noise must be made quite explicit before debate continues. An ensemble of apparently randomly excited discrete oscillators is in some contexts considered noise, and may be a good description of the sun. But such noise is not devoid of information, and analysis of it may tell us as much about the solar interior. More important is Fossat's claim that the source of the noise is the terrestrial atmosphere. This was argued from some knowledge of only the temporal behaviour of atmospheric refractive index fluctuations and must be substantiated by measurements of spatial coherence.

The three years of phase coherence of the 2^h40^m oscillations reported by Kotov, Severny and Tsap makes the interpretation as large scale solar vibrations most plausible. I should point out that Brookes, Isaak and van der Raay at Birmingham, who are unable to be at this meeting, have independently observed oscillations almost in phase with the Russian results, in an Na line of light integrated from the entire solar disk. Worden and Simon's interesting analysis shows that supergranulation may be an important factor contaminating a power spectrum of the data, but it is not an explanation of the 2^h40^m oscillation since the superposed epoch analysis filters out phase incoherent signal. Moreover, the phenomenon influences the Russian and UK measurements differently, and so would be unlikely to lead to phase agreement.

Solar oscillations have important theoretical implications. For example, they provide a potential tool for diagnosing the internal structure of the sun. Since the amplitudes are so low linear theory is adequate for computing the frequencies, and the existence of the oscillations does not upset the hydrostatic and energy balance deep inside the sun. It is important to realise that frequency information alone is insufficient because the spectra are too dense to enable one to identify the modes. It is essential to measure spatial structure so that the appropriate spherical harmonics characterizing the oscillations can be determined. The data will be useful only if phases are maintained for many periods, as in the case of the 2^h40^m oscillation, so that accurate frequency measurement is possible: the periods form almost a harmonic sequence and it is only the deviations from such a sequence that contain detailed information about the sun's structure. The internal solar rotation might be inferred from rotational splitting of degenerate non-radial modes.

It is also important to try to understand the mechanism that excites the oscillations. Random excitation by the turbulence in the convection zone seems most likely, but a thorough analysis has not been made. Goldreich and Keeley have estimated amplitudes ignoring the reaction of the oscillations on the convection, and have obtained values much too low, both for the oscillations discussed here and for the five minute oscillations. The apparent concentration of power into a single g mode, which seems to be implied by the Doppler data, suggests resonant driving by the p modes.

Oscillations provide a potential mechanism for transporting angular momentum. If the solar core is as quiescent as current folklore tells, dissipation in most places is so weak that coupling between the core with the surface by the modes discussed here takes place on a time-scale longer than the solar age. But more rapid dissipation of long period gravity waves generated by the large cells at the base of the convection zone does seem likely. Moreover, many of the modes may be absorbed in critical layers, which would lead to severe inhomogeneities in the distribution of angular velocity, and consequent meridional circulation and material mixing.

Dissipation of oscillations may be a significant factor in the energy balance of the solar atmosphere. Indeed it may be responsible for the latitude dependence of the limb darkening function observed by Hill and his collaborators in their study of the solar oblateness. If this is what is responsible for Dicke's oblateness data, then the 12.2^d precession of the oblateness reported recently by Dicke is presumably a beating between two rotationally split quadrupole modes. This provides an integral measure of the solar rotation which, whatever the modes that are presumed to be split, implies that the interior mean angular velocity exceeds maximum surface value. On the other hand, this interpretation also renders it most unlikely that the oblateness of the solar gravitational field is sufficient to have a significant influence on planetary orbits.

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7. Large-Scale Solar Motions (Dr H. Wöhl)

The review began with a short description of several theoretical ideas to explain the solar differential, rotation and the problems connected with them. The main section of the review contained the observational aspects of large-scale solar motions. The well known motions of sunspots detected by tracer techniques were mentioned. The main result is that the plasma and the solar fine structures show different rotation velocities at the equator and that the amount of the differential rotation is also quite different. Almost no differential rotation was found for long lived magnetic features and coronal holes.

The motions of Ca^+-mottles of the quiet sun which have been studied since 1974 rather extensively by E. H. Schröter and the author at the Swiss station of the Göttingen Observatory were described in more detail. The most important result is the detection of a giant circulation cell pattern within the equator belt in early summer 1975. Several attempts to search for a similar giant circulation pattern of four antisymmetric cells crossing the equator in photospheric layers by using Doppler shift measurements were unsuccessful.

8. Variations in Solar Activity and Rotation (Dr J. Eddy)

Although the early part of the sunspot number curve is not well documented, the 17th century shows a major anomaly (the Maunder minimum) when no spots were observed on the N. hemisphere of the sun for 43 years and no spots at all for up to 10 years. The 11-year cycle was also absent, a fact that was a matter of contemporary concern. The rarity of aurorae, lack of eclipse sightings of the corona and C^{14} data all agree in showing that this was a period of low activity.

Records of aurorae, coronal sightings and C^{14} data go back to about 5000 B.C. and all show variations in activity. There was a maximum in about 1200 A.D. and there were at least 5 periods of essentially zero activity. There is however no sign of a long term periodicity.

Studies of sunspot drawings by Scheiner and Hevelius suggest that the rotation period of the sun was about 1 day shorter during the Maunder minimum than it was beforehand, when the rotation rate was essentially equal to the present-day rate.

27 August 1976

SCIENTIFIC MEETING

1. Solar Neutrinos (Dr M. J. Newman)

While work continues towards the development of alternative and independent techniques, observational evidence concerning the flux of neutrinos from the sun at present is offered only by the ^{37}Cl experiment of Raymond Davis and his collaborators at the Brookhaven National Laboratory. This is in a sense unfortunate, for the energy of the copious flux of neutrinos believed to be produced by the basic proton-proton reaction is below threshold for the ^{37}Cl detector, and the high-energy neutrinos from the PP II and PP III completions (^7Be and ^8B decays) which produce the bulk of the counts on ^{37}Cl predicted by standard solar models can be quenched in a variety of ways. A definite test of the essential correctness of our understanding of solar structure and energy generation can only be provided by an experiment of increased sensitivity, and preferably one sensitive to the presence or absence of the low-energy neutrino flux.

Although the Brookhaven experiment is currently indicating a counting rate on ^{37}Cl of about 1.5 ± 0.5 SNU (one Solar Neutrino Unit = 10^{-36} capture per second per target atom) and standard solar models predict about 5 ± 1.5 SNU, the extreme temperature sensitivity of the branches leading to the troublesome high-energy neutrinos has provided theorists with several possible escape routes. None, however, have proved entirely convincing.

Straightforward attempts at reducing the central temperature, such as appealing to significant differential rotation, large interior magnetic fields, or a reduced opacity coefficient, encounter difficulties: oblateness measurements constrain the possibilities for differential rotation, the magnetic fields required are improbably large, errors in the opacity calculation, if present, are more likely in the opposite direction from that required. The opacity could be reduced if the surface composition was not representative of the interior metallicity, but the differential required is considerable, and problems exist for achieving the required surface contamination. Non-radiative energy transport has been suggested as a possibility for depressing the mean temperature gradient, but known processes are inadequate.

The central temperature could also be depressed by increasing the rate of energy generation possible at a given temperature. The ^{3}He-mixing approach achieves low neutrino-counting rates at present by transporting large amounts of fragile ^{3}He into hot regions, providing a transient energy source; but it has not been shown that the required mixing has occurred. Non-nuclear sources of energy have been considered, but are perhaps not very convincing. It has been suggested that the proton-proton rate, which dominates the energy generation in standard solar models, may be seriously in error, but this is unlikely.

The neutrino-counting rate for the ^{37}Cl experiment can be depressed while actually increasing the central temperature, if the distribution function for mutual ion velocities in the solar interior departs from the Maxwellian in the sense that particles farther out on the tail are preferentially depleted. That condition, however, has not been shown to hold.

Hoyle has found low counting rates in his solar models with a cosmological convective core, and Prentice has found similar models in his study of possibilities for the origin of the solar system. Several authors have found low counting rates for solar models in which the gravitational constant is a function of position.

Many other suggestions have been made in the literature. In summary, one must say that all of the low-neutrino-counting-rate models which have been offered to date are implausible to greater or lesser extent, and the solar neutrino problem remains serious. A conclusive test of our ideas concerning solar structure, however, awaits further experimental developments.

2. Periodic Full Amplitude Calculations for Double Mode Cepheids (Drs A. N. Cox and S. W. Hodson)

The dozen or so double mode or beat Cepheids have masses between one and two solar masses as determined by matching the ratios of the observed two or three periods (2-6 days) with results from the radial linear nonadiabatic theory. The mass of a typical one of these variables, U Tr A (2.568 and 1.825 days), is 1.2 $M_\odot$, less than half the evolutionary mass at the T_e necessary to be in the pulsational instability strip. Theoretical nonlinear results of Stellingwerf previously indicated that this double mode behaviour might be possible at very cool temperatures, now however thought to be beyond the red edge. Nonlinear initial value studies of purely radiative 1.6 $M_\odot$ models at the predicted 5800 K, or even cooler at 5600 K did not show the mixed mode behaviour, leaving in question the required double mode conditions. Cool 1.2 $M_\odot$ models also give only pure mode pulsations. New Los Alamos periodic nonlinear solutions at 1.6 $M_\odot$ using the same method as Stellingwerf give model stability for both the fundamental and first overtone modes, confirming the initial value hydrodynamic studies. Low masses, such as these stars seem to have, should not evolve to the pulsational instability strip according to evolution calculations. If they were more massive during earlier evolution, the mass loss could not exceed ten per cent if there is direct evolution from the red giant tip region to the pulsational instability strip. Maybe these double mode Cepheids are mode switching at the transition line in the instability strip, but where they are in the instability strip their anomalous masses need further explanation.

3. Convection in RR Lyrae Models (Dr R. G. Deupree - read by Dr A. N. Cox)

RR Lyrae models including convection have been computed by nonlinear numerical integration of the conservation equations in two spatial dimensions and time. Convection arises naturally from unbalanced buoyancy forces in convectively unstable regions and hence no phenomenological theory of convection is required. A red edge of the instability strip is found with this approach. Convection need be important only in the hydrogen ionization region for pulsation to be quenched. The quenching is achieved by time dependent convection altering the thermal structure in such a way so as to negate the traditional driving mechanisms. The red edge becomes slightly bluer as the helium abundance is decreased, making the width of the instability strip a sensitive indicator of helium abundance. A value of $Y \sim 0.3$ for globular cluster RR Lyrae stars is indicated.

4. Excitation of Pulsation in Stellar Convection Zones (Dr W. Unno)

Dynamical as well as thermodynamical coupling between the convection and the pulsation are evaluated by use of the mixing length treatment for the time dependent convection. Dynamical coupling occurs through the turbulent pressure and the eddy viscosity. It can be as important as the thermodynamical coupling which includes the κ-mechanism and the Cowling-Spiegel-Souffrin mechanism. The convective flux is shown to have destabilizing effects especially for the g-mode oscillations.

5. Helium Abundance Estimation of Disk K-Dwarfs from their Position in an Empirical ($\log T_{eff}$, M_{bol}) Diagram (Drs M. N. Perrin, G. Cayrel de Strobel and P. M. Hejlesen)

There is some evidence that the observational width of the main sequence limited to disk stars ($-0.62 < [Fe/H]_{\odot}^{*} < +0.50$, effective temperatures lower than 5500^{o}K) is not well explained by a variation of the metal/hydrogen ratio alone. It seems necessary to assume the existence in the stars of a simultaneous variation of the helium content with the metal content (roughly $\Delta Y \simeq (5 \pm 3)\Delta Z$), which acts in the opposite way to the metal content on the position of the observational ZAMS.

6. On the Evolution of Massive Stars Through the Core Carbon-Burning Phase (Drs S.A.Lamb, I. Iben Jr., and W. M. Howard)

Complete stellar models of Population I composition ($X = 0.7$, $Z = 0.02$) and of mass 15 $M_{\odot}$ and 25 $M_{\odot}$ are evolved from the main-sequence phase into the shell carbon-burning phase. By using a fine grid of mass shells throughout the evolution, and a full reaction network for the carbon-burning phase, care is taken to follow detailed changes in the chemical composition and in the physical parameters of the models.

Both the 15 $M_{\odot}$ and 25 $M_{\odot}$ models ignite helium as blue supergiants and remain blue supergiants through most of the core helium-burning phase. The 15 $M_{\odot}$ model ignites carbon as a red supergiant, whereas the 25 $M_{\odot}$ ignites carbon well to the blue of the red supergiant branch. We conclude that the longest period Cepheids ($P \gtrsim 126$ days) are massive stars ($\gtrsim 18\ M_{\odot}$) in the core carbon-burning phase of their evolution.

A comparison of the times spent by our 15 $M_{\odot}$ stellar model first as a blue, then as a yellow, and finally as a red supergiant with the supergiant statistics presented by Humphreys and Wildey indicates that the majority of red supergiants cannot be massive stars. We suggest that between 3/5 and 3/4 of the red supergiants are stars of intermediate mass ($1 \lesssim M/M_{\odot} \lesssim 9$) with helium- and hydrogen-burning shells above a carbon-oxygen core. For such stars to coexist with more massive stars currently burning carbon it is required that, in a typical OB association, star formation should have taken place over a period of time comparable to the main-sequence lifetime of a 7.7 $M_{\odot}$ star (i.e., $\sim 3 \times 10^7$ years).

We find that the envelope ratio of ^{14}N to ^{12}C is enhanced by a factor of 5 over the initial envelope ratio of both the 15 $M_{\odot}$ star, and the 25 $M_{\odot}$ star, and this material could eventually make a significant contribution to the enhancement of ^{14}N in the interstellar medium.

7. Turbulent Diffusion in Stars (Dr E. Schatzman)

The depletion of lithium in giants seems to result from the destruction of lithium on the main sequence prior to the formation of the giants. Lithium is carried by turbulent diffusion towards the regions where it is burned. The measurement of the abundance of lithium in giants gives the possibility of determining the rate of transport. It turns out that a turbulent diffusion coefficient $D = Re^{*}\nu$, where ν is a kinematic viscosity, and Re^{*} a constant, a sort of Reynolds number, explains the depletion of lithium on the main sequence. The depletion of lithiun in the Sun is compatible with the loss of angular momentum of the Sun. The same value of Re* suggests an explanation of the (V sin i) distribution function for main sequence stars and for giant stars. The value of Re* is around 180. A possible explanation of the number Re* is the following. Differential rotation can induce a turbulence which has the tendency to establish near solid body rotation. The decrease in the gradient of angular velocity stops the turbulence. Transport processes are then due to microscopic viscosity. Loss of angular momentum re-establishes a larger gradient of angular velocity, which regenerates turbulence. Assuming that the star is always marginally unstable with respect to turbulence gives the possibility of relating Re* to the critical Reynolds number for the onset of turbulence, $Re^{*} = (1/9)Re(\text{critical})$. It leads to Re* of the order of 170.

8. Diffusion and a Lower Limit to the Mixed Mass in the Solar Envelope (Dr G. Michaud)

If one wishes to assume that the heavy elements on the solar surface were accreted by the sun, one must remember that either the zone immediately below the surface convection zone is stable enough for diffusion to be important or other transport processes (i.e. turbulence, meridional circulation), more efficient than diffusion, will tend to homogenize the star. Diffusion is the slowest of the transport processes and will become important as soon as the other transport processes become inoperative. Diffusion theory then allows one to determine the minimum mass of the convection zone, if transport processes at the bottom of the convection zone are not to influence the abundances in the convection zone. If diffusion time scales, θ, are shorter than, or of the order of, the life of the star, diffusion will modify the abundances in the convection zone. The diffusion theory gives $\theta \sim 2 \times 10^{11}\, \Delta M_c^{0.535}$ (years), with ΔM_c in units of $M_{\odot}$. The mass in the convection zone for which diffusion does not modify surface abundances in the sun by more than a factor of two is around 3×10^{-3} $M_{\odot}$. It is larger than the mass assumed in most, but not all, of the accretion models, which are so ruled out.

9. Astrophysical Opacity Library at Los Alamos Scientific Laboratory (Drs W.F. Huebner, A. L. Merts, N.H.Magee Jr., and M.F.Argo)

The main contents of the astrophysical elements opacity library is composed of equation of state data, radiative Rosseland mean opacity, Planck mean opacity, electron conduction opacity, total (combined radiative and electron conduction) Rosseland opacity, and 2000 values of the frequency dependent extinction coefficients

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in equally spaced intervals of $\Delta u = 0.01$ from $u \equiv h\nu/kT = 0$ to 20. Among available auxiliary quantities are the degeneracy parameter (η), the free electron density, the number of free electrons per atom (N_f), the mass density, and the plasma cutoff frequency.

The basic library contains the following 20 elements: H, He, C, N, O, Ne, Na, Mg, Al, Si, P, S, Cl, Ar, Ca, Ti, Cr, Mn, Fe, and Ni. Since the library is intended to produce opacities for astrophysical mixtures by matching the electron pressures for each constituent, molecules are by necessity excluded. To match the electron pressures, a standard grid is set up for all elements as a function of temperature, T, and degeneracy parameter, η. The temperature range is from kT = 1eV ($\approx$ 11600 K) to 10 keV with ten approximately logarithmically spaced grid points for each decade. A few additional points are supplied between 10 and 100 keV. The η grid goes in steps of 1 from $\eta = -25$ to -1, and then in increasing steps up to 500. The T-η grid is, however, only piece-wise rectangular: the area of very negative η (non-degenerate, very low density) and very high T is of little interest. The area of high degeneracy ($\eta > 0$) at low T is only considered as long as the Coulomb interaction between ions (with effective charge N_f), $(N_f\, e)^2/(r\, kT) \lesssim 1$, where r is the mean separation between ions. This limits approximately the density range from $\rho \approx 10^{-12}$ to 10^{-3} g/cm^3 at kT $\approx$ 1 eV, and $\rho \simeq 10^{-3}$ to 10^7 g/cm^3 at kT $\approx$ 10 keV.

The mixing program requires as input the chemical element composition (atomic number abundance, atomic weight abundance, or log weight abundance on a scale on which H is 12), and the temperature-density grid. The library contains the improvements given by Magee, Merts and Huebner (Astrophys.J. 196, 617, 1975). Additional important improvements include the use of non-hydrogenic bound-free cross sections and effects due to level broadening. Progress is being made on a program consistent with the opacity library to calculate molecular effects.

COMMISSION 36: THE THEORY OF STELLAR ATMOSPHERES (LA THEORIE DES ATMOSPHERES STELLAIRES)

Report of Meetings, 25 and 26 August 1976

PRESIDENT: R. Cayrel SECRETARY: F. Praderie

Business Meeting, 25 August 1976

Mr. N. Heidmann was appointed acting secretary in the absence of F. Praderie.

I. ELECTION OF PRESIDENT AND VICE-PRESIDENT

The first topic was the election of the new President and the new Vice-President. Dr. D. Mihalas was elected new President with 15 votes for and none against. Dr. G. Traving was elected new Vice-President with 17 votes for and none against. These two votes were taken by secret ballot. Before the second vote a short discussion took place on the fact that Dr. V.V. Sobolev had not accepted to be candidate for the vice-presidency.

II. ELECTION OF ORGANIZING COMMITTEE

After a discussion and taking into account proposals from the floor a positive vote was taken on the following list of names for the new Organizing Committee: Hearn, A.G. ; Jefferies, J.T.; Kodaira, K.; Kuhi, L.V.; Marlborough, J.M.; Pagel, B.E.J.; Praderie F.; Saper, A.A.; Vardye, M.

III. ADMISSION OF NEW MEMBERS

The President proposes a list of 24 names for new members of the Commission. *Five other names are proposed from the floor. A final list of 29 names is accepted,* subject to the condition, for those not yet member of the Union, of becoming member of the Union at the sixteenth General Assembly. The list reads as follows: Altrock R.C. (U.S.), Bell R.A. (U.S.), Blanco (I), Boesgaard A. (U.S.), Carbon D. (U.S.), Castor J.I. (U.S.), Cowley C.R. (U.S.), Davis C.G. (U.S.), Evangelinis E. (Gr.), Foy R. (F), Gail H. (D), Gray D.F. (Can.) Gustafsson B. (S), Heidmann N. (F), Hekela J. (Gr.), Holweger H. (D), Kodaira J. (J), Kolesov A.K. (USSR), Lambert D.L. (U.S.), Linsky J.L. (U.S.); Matsumoto M. (J), Mukai S. (J), Pasinetti L. (I), Reimers D. (D), Seldmayr E. (D), Thompson R.I. (U.S.), Tsuji J. (J), Wehrse R. (D), Wickramasinghe C. (U.K.).

IV. SUPPORT OF THE COMMISSION FOR IAU SYMPOSIUM

The Commission decides to give support to a symposium on "Turbulence and mass loss in stellar atmospheres" to be held in connection with the XVII th General Assembly in Canada in 1979. This symposium results from joining two separate proposals from D.F. Gray and J.M. Marlborough from one side and from J.L. Linsky from another side. This symposium could be given in honour of O.C. Wilson for his outstanding work on chromospheric H and K emission in stars. The Commission proposes Gray, Marlborough and Linsky as members of the Organizing Committee of the symposium.

The Commission *also gives support to a project of symposium on the HR diagram* linked to the 100th anniversary of Russel (proposed by A.G.D. Philip) to be held in 1977 in the U.S.

A discussion takes place on other possible topics for symposia or colloquia of interest for Commission 36. It is decided that the new President will circulate a letter among the members of the Commission relative to this topic.

The session is closed at 10:30 a.m.

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Scientific Sessions: August 26, 1976

The scientific sessions, initially planned for August 27 morning, took place on August 26 afternoon in order to avoid an overlapping with the scientific meeting of Comission 44 on ultraviolet stellar astronomy: "stellar mass loss and coronae".

The first session was devoted to "Competitive line broadening" and included the following contributed papers:

(1) Empirical evidence for competition between microturbulence and collisional broadening at the first turn-off of the solar and stellar curves of growth of FeI by R. Foy.

(2) Recent theoretical works on collisional broadening of spectral line by N. Feautrier.

(3) Fourier analysis of line profiles for turbulence and rotation, by D. Gray.

The second session was devoted to the topic "how to deal with molecules in stellar atmospheres" and included the following contributed papers:

(1) Effects of molecular absorption on the temperature profile of cool stellar atmospheres by G. Gustafsson.

(2) LTE or non LTE for molecules in stellar atmospheres, by D.L. Lambert.

(3) On the treatment of atomic and molecular opacities by H.R. Johnson.

The Commission 36 has also taken part in several joint meetings and in the joint discussion number 5 on "stellar atmospheres as indicator and factor of stellar evolution".

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COMMISSION 37: STAR CLUSTERS AND ASSOCIATIONS (AMAS STELLAIRES ET ASSOCIATIONS)

Report of Meetings, 27, 30, and 31 August 1976

PRESIDENT: I. R. King SECRETARY: R. Wielen

27 August 1976

BUSINESS SESSION

Because of scheduling constraints, it was necessary to precede this day's scientific meeting with a brief business session. The slate of new officers was approved, and likewise the list of proposed new members of the Commission. Since the list of proposed new members would undoubtedly include individuals who were not yet being elected to I.A.U. membership, it was agreed that such persons would be given the status of consultants to the Commission, for the 3-year period that ends with the next I.A.U. General Assembly. This accomplishes the purposes of the Commission without disturbing the orderly procedures of I.A.U. membership.

SCIENTIFIC SESSION

All of the scientific sessions of the Commission were conducted in an informal way. A number of individuals had been invited by the President to present reviews of areas that are of interest to the Commission. Each review was followed by an extended discussion period, during which participants also had an opportunity to deliver very brief reports.

The reviews presented at this session were as follows:
G. Clark: X-ray Sources in Globular Clusters.
G. Larsson-Leander: Stellar Associations.
W. F. van Altena: Astrometry in Clusters and Associations.

30 August 1976

SCIENTIFIC SESSIONS

The following reviews were presented:
A. F. J. Moffat: Young Clusters.
T. G. Hawarden: Older Open Clusters.
P. R. Demarque: HR Diagrams and Stellar Evolution.
G. D. Illingworth: Southern-Hemisphere Programs.
R. Wielen: Dynamics of Star Clusters.
W. E. Harris: Distribution of Globular Clusters in the Galaxy (presented by I. R. King).

31 August 1976

BUSINESS SESSION

The Report of the Commission was accepted without comment. The President stated that additions and corrections to the Report would be included in the present report (see below).

The Commission agreed to endorse two proposed I.A.U. symposia:

(a) "The HR Diagram," proposed by A. G. D. Philip for October 1977, possibly at Albany, N. Y., U.S.A.

(b) "Star Clusters," proposed by S. van den Bergh for a time just prior to the 1979 General Assembly. This symposium would be held in Toronto, Canada.

Dr. B. Balázs reported on the status of the Catalogue of Star Clusters and Associations. The First Supplement to the second edition is in press and will hopefully appear in the Spring of 1977, unless it is further delayed by financial problems. The Commission agreed to request that the I.A.U. Executive Committee grant a subsidy of $1000 (or as close to that amount as possible) toward the expenses of this publication.

Dr. Balázs reminded the Commission of the importance of communication of results, and the Commission thereupon adopted the following resolution:

"Recognizing the importance of the Catalogue of Star Clusters and Associations to all astronomers, Commission 37 urges all observers to send copies of their papers directly to the Editors of the Catalogue, B. Balázs or J. Ruprecht (open clusters and associations), or R. E. White (globular clusters)."

There was some discussion of the future form of the Catalogue, especially in view of its increasing size. It was agreed that the third edition should be prepared in machine-readable form and that it should be made available through the Stellar Data Center in Strasbourg.

Dr. A. G. D. Philip described a collection of globular-cluster HR diagrams published by himself, Cullen, and White (Dudley Obs. Report No. 11).

The President called attention to an appeal by Dr. B. V. Kukarkin for preprints and reprints for use in preparing the second edition of his book "Globular Star Clusters."

The Commission discussed the question of nomenclature of star clusters. There was general agreement that the traditional system of nomenclature has become unwieldy and that a new system should be devised. Although it is clear that a new nomenclature ought to be based on some regular coordinate system, it is not obvious which coordinates should be used, or what sort of notation. A Working Group on Nomenclature was appointed; its members are A. F. J. Moffat (Chairman), B. Balázs, J. Ruprecht, W. L. Sanders, and R. E. White.

SCIENTIFIC SESSION

One review was presented:

R. E. White: Globular-Cluster HR Diagrams.

Appendix

CORRECTIONS AND ADDITIONS TO COMMISSION REPORT

(Since the submission of the Commission Report, a number of errors have been called to the attention of the President, along with some additions that should be made. The President wishes especially to express his apologies to the Basel Observatory, whose contribution was omitted through an oversight on his part.)

W. E. Harris (Yale) has redetermined distances of 111 globular clusters and discussed their distribution in the Galaxy (Astron. J., in press). R. F. Garrison (Toronto) is determining integrated spectral classes and Morgan metallicity classes for 60 globular clusters. G. Alcaino (ESO) has determined preliminary photometric distances to 43 faint globular clusters south of $\delta = -22°$, and he has completed a general study of morphological data for globular clusters in the Galaxy.

A sixth globular-cluster X-ray source has been found, through the discovery by Liller (Harvard) of an obscured globular cluster of high central concentration, at the position of an observed X-ray source.

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In the following supplements to the tables in the Report, "c" identifies corrections to previous items, while "a" means that the item is an addition.

1. Supplement to Table 1 (Associations)

a	Ara	R1	Herbst, Havlen (York, ESO) UBVRI, sp.
a	CMa	R1	Herbst, Racine (York, Toronto) UBV, sp.
c	Cyg	T1	observer is Gieseking
a	Mon	R2	Herbst, Racine (York, Toronto) UBV, sp.

2. Supplement to Table 2 (Open Clusters)

a	188	Helfer (Rochester) UBVIyz
a	559	Grubissich RGU (*Astron. Astrophys. Suppl.*, in press)
a	637	Grubissich RGU (*Astron. Astrophys. Suppl.*, in press)
a	1027	Helfer (Rochester) UBVIyz
a	1502	Hagen-Harris (Yale) sp., r.v.'s
a	1528	Helfer (Rochester) UBVIyz
a	1647	Helfer (Rochester) UBVIyz
a	1778	Helfer (Rochester) UBVIyz
a	2169	Hagen-Harris (Yale) r.v.'s
a	2323	Hagen-Harris (Yale) sp., r.v.'s
a	2421	MacConnell (Mérida) UBV, E(B-V), Be stars
a	2422	Hagen-Harris (Yale) sp., r.v.'s
a	2423	Hassan (Cairo, Basel) UBV
a	2546	Hagen-Harris (Yale) sp., r.v.'s
a	2670	Hagen-Harris (Yale) sp.
c	2682	Pulkovo: Kadla, Frolov p.m., UBV, c-m
a	2910	Topaktas (Istanbul, Basel) UBV
a	2925	Topaktas (Istanbul, Basel) UBV
a	3114	Hagen-Harris (Yale) sp., r.v.'s
a	3532	Hagen-Harris (Yale) sp., r.v.'s
a	3766	Hagen-Harris (Yale) r.v.'s
a		Yilmaz (Istanbul, Basel) RGU
a	5168	Fenkart (Basel) RGU
a	5316	Hagen-Harris (Yale) sp.
a	5617	Hagen-Harris (Yale) sp.
a	5822	Hagen-Harris (Yale) sp.
a	6031	Topaktas (Istanbul, Basel) RGU
a	6383	Hagen-Harris (Yale) sp.
a	6405	Hagen-Harris (Yale) sp., r.v.'s
a	6416	Hagen-Harris (Yale) sp.
a	6425	Hagen-Harris (Yale) sp.
a	6494	Hagen-Harris (Yale) sp.
a	6633	Hagen-Harris (Yale) sp.
a	6673	Helfer (Rochester) UBVIyz
a	6705	Helfer (Rochester) UBVIyz
a	6755	Helfer (Rochester) UBVIyz
a	6882/5	Helfer (Rochester) UBVIyz
a	7062	Helfer (Rochester) UBVIyz
a	7063	Helfer (Rochester) UBVIyz
a	7209	Helfer (Rochester) UBVIyz
c	7243	Pulkovo p.m. by Koroleva
c	7788	Pulkovo: Frolov p.m., UBV, c-m
c	7789	omit Pulkovo reference
c	7790	Pulkovo: Frolov p.m., UBV, c-m
a	IC 1805	Helfer (Rochester) UBVIyz
a	IC 2395	Hagen-Harris (Yale) sp.
a	IC 4725	Helfer (Rochester) UBVIyz

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2. Supplement to Table 2 (Open Clusters) [continued]

a	IC 4756	Helfer (Rochester) UBVIyz
a	Ba 11a	Grubissich RGU (*Astron. Astrophys. Suppl*. 11, 283, 1973)
a	Ba 16	Fenkart (Basel) RGU
a	Be 6	Spaenhauer (Basel) RGU
a	Be 58	Frolov (Pulkovo) p.m., UBV, c-m
a	Cr 140	Hagen-Harris (Yale) sp., r.v.'s
a	Cr 272	Fenkart (Basel) RGU
a	Cr 299	Topaktas (Istanbul, Basel) RGU
a	H 10	Topaktas (Istanbul, Basel) RGU
a	Lyngå 6	Lyngå says really a cluster (*Astron. Astrophys*., in press)
a	Mel 71	Hassan (Cairo, Basel) UBV
a	Ru 79	Topaktas (Istanbul, Basel) RGU
a	Ru 82	Topaktas (Istanbul, Basel) RGU
a	Stock 2	Hagen-Harris (Yale) sp., r.v.'s
a		Helfer (Rochester) UBVIyz
a	Stock 16	Fenkart (Basel) RGU
a	Tr 2	Hagen-Harris (Yale) sp., r.v.'s
a		Helfer (Rochester) UBVIyz
a	Tr 10	Hagen-Harris (Yale) sp., r.v.'s
a	Anon Feinstein	Hagen-Harris (Yale) sp., r.v.'s
a	Anon	Frolov (Pulkovo) p.m., UBV, c-m

3. Supplement to Table 3 (Globular Clusters)

a	362	Alcaíno (ESO) UBV, c-m
a	1904(M79)	Alcaíno (ESO) UBV, c-m
a	3201	Alcaíno (ESO) UBV, c-m
a	4590(M68)	Alcaíno (ESO) UBV, c-m
c	5024(M53)	Panova (Pulkovo) p.m., BV, c-m
c	5272(M3)	Kadla *et al*. (Pulkovo) distr. of RG, UBV, surf. phot.
a	5904(M5)	Bashtova (Pulkovo) p.m., BV, c-m
a		Kadla *et al*. (Pulkovo) distr. of RG, BV, surf. phot.
a	6205(M13)	Kadla *et al*. (Pulkovo) distr. of RG, UBV, surf. phot.
c	6341(M92)	Kadla *et al*. (Pulkovo) distr. of RG, UBV, surf. phot.
a		Cudworth (Yerkes) vel. disp. from p.m.
a	6397	Alcaíno (ESO), UBV, c-m
a	6656(M22)	Alcaíno (ESO), UBV, c-m
a	7078(M15)	Kadla *et al*. (Pulkovo) distr. of RG, UBV, surf. phot.
		Panova (Pulkovo) p.m.
		Cudworth (Yerkes) vel. disp. from p.m.
a	7089(M2)	Kadla *et al*. (Pulkovo) UBV

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COMMISSION 38: EXCHANGE OF ASTRONOMERS
(ECHANGE DES ASTRONOMES)

Report of Meetings, 26 and 30 August 1976

PRESIDENT: P. M. Routly VICE-PRESIDENT: D. A. MacRae

Present at both meetings were the President and Vice-President, P. M. Routly and D. A. MacRae, all six members of the Organizing Committee, J. Delhaye, G. S. Khromov, A. Reiz, J. Sahade, F. G. Smith, and F. B. Wood, and some fifteen general members and interested participants.

The President began by giving a verbal report of the procedures and criteria that were followed in administering the Exchange of Astronomers Program since the XVth General Assembly in Sydney. While unanimously approved by the Commission members, the President pointed out the continuous need to justify the existence of the Program, to re-affirm its objectives, and to devise new ways in which the Program might be improved in the future.

Accordingly, after full discussion and debate, the Commission recommended for adoption the following restatement of Program Aims, Minimum Requirements, Guidelines, and Application/Selection Procedures.

Exchange of Astronomers Program

I. BASIC AIMS

To award grants to qualified individuals to enable them to visit institutions abroad for the purpose of working on problems which they could not pursue advantageously in their own countries. It is hoped, in particular, that each visitor have ample time and opportunity to interact with the intellectual life of the Host Institution so that scientific and cultural benefit is derived on both sides. It is a specific objective of the program that astronomy in the home country be enriched after the applicant returns.

II. MINIMUM REQUIREMENTS

(1) Each candidate must submit a curriculum vitae showing that he/she is professionally qualified and must submit a viable plan of scholarly activity to be carried out during the proposed visit.

(2) Candidates may be faculty/staff members, post-doctoral fellows, or graduate students at any recognized educational/research institution or observatory. All candidates must have excellent records and must have made permanent and professional commitments to astronomy.

(3) All visits must be formally agreed to by the Directors of the Home and Host Institutions involved. Such endorsements must confirm that the proposed plan of study is a reasonable one and will be of benefit to astronomy.

(4) All visits must consist of a stay of at least 3 months at a single Host Institution. Stop-overs at other Institutions en route may be permitted.

(5) Each applicant must give details, with supporting documentation, of funds currently available to him to finance his proposed visit. In particular, the applicant must state what other applications he has submitted in efforts to obtain support from other sources and must indicate the status of such applications. In the event that an applicant receives funds from another source which may be used, in whole or part, for the same proposed visit, he is required to revise his application or make a refund to the I.A.U.

(6) Each recipient is required to submit a brief report to the President of Commission 38 after the conclusion of his visit. Acknowledgement of support from the I.A.U.'s Exchange of Astronomers Program should also be made in any published paper resulting from a visit.

III. GUIDELINES

(1) Grants are made within limitations imposed by the budget allocated to the Commission by the Executive Committee of the Union.

(2) The amount of a grant will be governed by the cost of a single return economy air fare between the Home and Host Institutions and normally is to be used by the applicant for such travel. In exceptional cases, and with prior Commission approval, the funds can instead be used wholly or in part for subsistence costs during the visit.

(3) Grants to attend symposia, summer schools, conferences, society meetings, etc. are outside the scope of the program.

(4) Grants will not be made for the sole purpose of obtaining observational data; other benefits to astronomy must also be realized during the visit.

(5) An individual should normally not expect to receive an I.A.U. award for a second visit.

(6) The Program is normally designed to support the work of young astronomers, but established astronomers who can benefit from the Program may also participate.

(7) Some grants may be awarded on the basis of one-way fare. Examples are visits of long duration - a year or more - or cases where highly qualified graduate students apply for funds to go abroad to begin graduate studies at an institution where they have been formally accepted.

(8) It is to be emphasized that all recipients should return to their Home Institutions or Home Countries upon the completion of their visits.

IV. APPLICATION AND SELECTION PROCEDURES

(1) Each applicant must formally submit his request for a grant in the form of a letter to the President of Commission 38. The information supplied in this one document should be complete and detailed as it will be used to judge whether the proposal is in conformity with the aims of the Program, whether the minimum initial requirements are being met, and whether the guidelines will permit a favorable decision. Any special circumstances must be carefully set forth.

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(2) It is the applicant's responsibility to arrange for two confidential letters of endorsement from senior officials of the Home and Host Institutions to be sent without delay directly to the President of Commission 38. The letters should, as well, confirm statements made by the applicant concerning his financial status and availability of support from sources other than the Exchange of Astronomers Program.

(3) Upon receipt by the President of a complete application, a copy will be sent to the Vice-President. These two officers of the Commission will jointly decide on the disposition of the application. Experience shows that the majority of applications can be dealt with effectively in this manner.

(4) If the application has unusual features rendering a decision difficult, if a significant deviation from the guidelines arises, if there is disagreement between the two officers, or for any other reason, the application will be distributed to members of the Organizing Committee for their opinions before a final decision is reached. In case of an appeal against an unfavorable decision, the Organizing Committee will be asked to adjudicate. In this way, the guidelines will be continuously under review and improved in the light of experience.

(5) When a favorable decision has been reached, the President will forward copies of the application and all pertinent documents to the General Secretary and will recommend that a grant be made in a specified amount.

(6) At six or eight month intervals during the triennium, the President will issue interim Reports on the Program to members of the Organizing Committee of the Commission and to the General Secretary for the information of the Executive Committee of the Union. The members of the Organizing Committee will be asked to comment on the operation of the Program on each such occasion.

(7) Brief summaries of Commission activities will also be distributed to general members of the Commission during the intervals between General Assemblies.

Another question which was discussed thoroughly was whether the Exchange of Astronomers Program should continue to be operated as in the past or whether the Program's objectives would be better served by a small ad-hoc committee of the Executive Committee.

Because of the desirability for the widest possible exposure to, and participation by, the international astronomical community, it was felt unanimously that the Exchange of Astronomers Program should continue to be operated by a full Commission, similar in structure to the other Commissions of the Union, and consisting of a President, Vice-President, Organizing Committee, and General Membership. Among the reasons in favor of a General Membership were the following - to provide a pool of potential members for the Organizing Committee, to optimize the opportunity for professional contact and the flow of information involving, especially, the smaller and/or less well developed countries and, finally, to provide a mechanism for interested members of the Union to participate directly in the affairs of the Commission.

It was therefore recommended that Commission 38 continue to operate the Exchange of Astronomers Program and that the composition of this Commission over the next three years be as follows:

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President: D. A. MacRae (Canada)

Vice-President: J. Delhaye (France)

Organizing Committee: M. K. V. Bappu (India), G. S. Khromov (USSR), A. Reiz (Denmark), P. M. Routly (USA), J. Sahade (Argentina), F. G. Smith (U.K.), F. B. Wood (USA).

General Membership: G. Abetti (Italy), A. W. Alsabti (Iraq), B. J. Bok (USA), H. F. Haupt (Austria), G. Keller (USA), V. Kourganoff (France), M. Marik (Hungary), J. M. Mohr (Czechoslovakia), S. Myamoto (Japan), S. E. Okoye (Nigeria), A. Opolski (Poland), T. L. Page (USA), G. Righini (Italy). S. Rosseland (Norway), G. Ruben (G.D.R.), R. H. Stoy (U.K.), P. Swings (Belgium), G. Teleki (Yugoslovia), C. R. Tolbert (USA), J. P. Wild (Australia), S. P. Wyatt, Jr. (USA).

It was also suggested that the General Secretary write the National Committees of each of the adhering countries of the Union not represented in the proposed membership above to ask whether they would like to be represented and, if so, by whom.

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COMMISSION 40: RADIO ASTRONOMY
(RADIO ASTRONOMIE)

Report of Meetings, 25, 26, 27, 28 and 30 August and 1 September 1976

ACTING PRESIDENT: H. van der Laan SECRETARY: R. G. Strom

JOINT DISCUSSIONS

On 25 August Commission 40 cosponsored a meeting with Commissions 34 and 44 on Interstellar Molecules and Dust.

On the afternoon of 26 August a joint discussion was held with Commissions 4, 8, 19 and 31 on New Techniques for the Determination of the Rotation of the Earth.

Commissions 40 and 48 held a joint discussion on Physics of Radio Sources and Quasars on 27 August.

These activities are outlined in one of the reports of the cosponsoring Commissions.

28 August 1976

In the unfortunate absence of the President, Yu. N. Parijskij, the Vice President took the chair. The following business was transacted.

I. REPORT OF THE ACTING PRESIDENT

Commission activities since the Sydney General Assembly were briefly summarized. The Acting President pointed out the changing character of Commission 40, particularly the fact that radio studies now embrace nearly all fields of astrophysics. In view of this, each Commission 40 member should also be a member of at least one other Commission where his purely astronomical interests can be represented.

II. ELECTION OF THE ORGANIZING COMMITTEE

The list of nominations for Commission Officers and Organizing Committee was adopted without change:

President: H. van der Laan

Vice President: G. Swarup

Organizing Committee: Blum, Fanti, McLean, Mezger, Moffet, H. P. Palmer, Parijskij, Robinson, Zuckerman.

III. RESOLUTION CONCERNING SYSTEM III FOR JUPITER

H. P. Palmer summarized a resolution on behalf of Bozyan, Riddle, Seidelmann and others, which was adopted by the Commission: 'RESOLVED, that the provisional rotation period adopted for Jupiter's System III (1957.0) longitude measure, being inadequate for current use, be replaced by a new System III measure for which the sidereal rotation rate of Jupiter is $870\overset{\circ}{.}536$ per Ephemeris day. The epoch shall be 1965 Jan. 1 $0^h0^m0^s$ ET, the longitude at epoch of the central meridian, as observed from Earth, shall be $217\overset{\circ}{.}595$, and the system shall be called System III (1965).'

IV. RESOLUTION CONCERNING THE STANDARD OF REST

Heidmann proposed, on behalf of De Vaucouleurs, a resolution which was adopted by the Commission: 'Commission 28, 30 and 40 RECOMMEND, that in the standard correction of extragalactic redshifts for solar motion with respect to the Local Group $\Delta V = 300 \cos A$, the definition of the solar apex be changed from $\ell^I = 57^\circ$, $b^I = 0^\circ$ to $\ell^{II} = 90^\circ$, $b^{II} = 0^\circ$, but that no change be made in the conventional value of the solar velocity $V_{\odot}$ = 300 km s^{-1}.'

V. RECOMMENDATION ON THE DEFINITION OF RADIAL VELOCITY

Menon outlined the conclusions of the joint working group set up by Commissions 30 and 40 in Sydney. There was considerable opposition to the introduction of a new symbol, v_{ν}, to define the fictional velocity $c\Delta\nu/\nu_o$. Therefore the original recommendations were modified, to be considered further by Commission 30:

(1) The practice of calling the quantity $c\Delta\nu/\nu_o$ a radial velocity, and denoting it by the symbol v_r is confusing in extragalactic applications and should be discontinued.

(2) Astronomers who insist on publishing results in the form $c\Delta\nu/\nu_o$ should clearly indicate that they have done so.

VI. PROPOSALS RECEIVED FROM OTHER COMMISSIONS

Note was taken of the following resolutions, for which there was general support in our Commission:

(1) Commission 8 urges the continued support and coordinated long term planning of meridian astronomy. (2) Commission 10 strongly recommends that ground based solar research not be neglected in favor of satellite-borne observations. (3) Hagen of Commission 10 requests coordination of solar flare reporting.

VII. REPORTS ON ASTRONOMY

Westerhout proposed a vote of thanks to Parijskij and his colleagues for the extensive bibliography they prepared for the Commission Report in Volume XVIA of the Transactions. This proposal met unanimous acclaim. After some discussion it was decided that account should be taken of the wide ranging character of Commission 40 in preparing future Reports. These could be more efficiently prepared in close consultation with other Commissions.

VIII. IUCAF NEWS

The discussion was dominated by the upcoming (1979) World Administrative Radio Conference (WARC), by interference from satellites and aircraft and by the need for protecting spectral lines.

A working group chaired by Robinson will look into the priorities for protection of frequency bands for molecular lines and report to IUCAF before 1 November 1976. It will also study protection for the 106-116 GHz band which contains many lines (especially CO), and consider whether the protected 130-140 GHz band should be exchanged for this. Barret was asked to look into protection for ammonia lines and submit a report to IUCAF

Westerhout summarized the activities of IUCAF for the remainder of 1976. These include rewriting proposals, contacting appropriate people and calling for cooperation in obtaining the required frequency protection.

Findlay proposed the following resolution which was passed by the Commission: 'The International Astronomical Union, CONSIDERING (a) that the World Administrative Radio Conference (WARC) to be held in 1979 will study the technical requirements and frequency allocations for all radio services, including the use of radio frequencies for scientific research purposes; (b) that the decisions of WARC-1979 can be expected to remain in force for about 20 years; (c) that the deliberations and recommendations of the Inter-Union Commission on Frequency Allocations for radio astronomy and space science (IUCAF) are the appropriate means of indicating the requirements for radio frequencies for research purposes; (d) that individual national administrations are now making preparations for WARC-1979; RESOLVES to encourage IUCAF, 1. to undertake in a timely manner the deliberations and studies required to determine the needs of radio scientists for the use of the radio spectrum; 2. to bring its recommendations to the attention of the members of URSI, IAU and COSPAR so that those bodies may comment on them; 3. to invite national

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TABLE 1. MILLIMETER RECEIVERS (from the review by P. Zimmermann)

Device	Ref. (see text)	Frequency Range (GHz)	Instantaneous Bandwidth (MHz)	Gain, G (dB); Conversion Loss, L (dB)	Noise Temp. (K)	Operating Temp. (K)	Remarks
Maser	(a)	29-35	30-60	G=30	$30\pm5^*$	4.2	
	(b)	35	20	G=20	-	-	
	(c)	85-90	140	G∿3-5	$<100^*$	4.2	upper frequency limit ∿100 GHz due to lack of high frequency pumps, and problems of circulator design
Parametric Amplifiers	(d)	33.6	900	G=15	$144^\dagger$	300	
	(e)	46	200	G=22	$40^\dagger$	18	
	(f)	60	200	G=18	605^*	300	
	(g)	∿60	800	G=14	850^*	315	
Josephson Paramp	(h)	33	3400	G=15	$220^\dagger$	4.2	20±10 K from the paramp alone; saturation problem; advantage of zero bias operation and low pump power required
Josephson Mixer	(i)	36	50	{L=5, G=1.35	$210-54^*$	4.2	pump power in the range of microwatts; bandwidth restricted by IF-amplifier
	(j)	220-325	100	L=12.3	71^*	4.2	
InSb Mixer	(k)	115	4	L∿10	$250^\dagger$	4.2	pump power only ∿0.1 μW; bandwidth restricted by element response time; expected to be used up to 500 GHz
		230	4	L∿10	$300^\dagger$	4.2	
Schottky-Barrier Mixer	(l)	85	100	L=4.6	420^*	300	limiting factor is diode quality; good up to >200 GHz with present diodes
		115	100	L=5.5	500^*	300	
		115	100	L=5.8	300^*	77	

*single side band

†double side band

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administrations to include the IUCAF recommendations, as appropriate, in the documents they will prepare for the CCIR and WARC-1979.'

Howard proposed a resolution which was passed by the Commission and subsequently by the General Assembly of the Union. (See Resolution No. 8.)

IX. FUTURE SYMPOSIA AND COLLOQUIA

International conferences being planned for the next three years were called to the attention of Commission members. These include symposia and colloquia being arranged in conjunction with the 1979 IAU General Assembly, a colloquium which will precede the 1978 URSI meeting in Helsinki and a conference on normal galaxies to be held in the summer of 1977. As these plans take shape Commission members will be informed through the IAU Bulletins or by circular letter.

X. MEMBERSHIP

Nominations for membership were reviewed by the Organizing Committee. A total of 64 new members were elected. Their names are incorporated in the current membership list.

XI. OTHER BUSINESS

Sullivan described a project in which he is collecting information bearing on the history of radio astronomy. He is particularly interested in original source material and appealed for help in locating any he may not be aware of.

Dixon announced that the master catalogue of radio sources continues.

30 August 1976

Two scientific sessions were held on the afternoon of 30 August.

I. TECHNICAL DEVELOPMENTS IN MILLIMETER ASTRONOMY

The meeting, chaired by M. A. Gordon, heard of recent developments in millimeter wave receivers, and the status of a number of millimeter telescope projects.

Millimeter Receivers (P. Zimmermann)

For radio astronomical and in particular spectroscopic measurements in the range 30-300 GHz receiver types employed are masers, parametric amplifiers, Josephson junction devices, InSb-bulk mixers and Schottky-barrier mixers. Existing receivers which have been reported in the literature and their salient features are listed in Table 1. (References to Table 1 are: (a) Cardiasmenos et al. June 1976, IEEE-MTT Int. Microw. Symp.; (b) Zagatin et al. 1976, Radio Eng. Electr. Phys., 12, 501; (c) Kolberg and Lewin. 1976, IEEE Trans. Microw. Theory Techn., 24, in press; (d) Cohn et al. 1969, IEEE G-MTT Int.Microw. Symp. Dallas; (e) Edrich. 1973, Int. Microw. Symp. Dig. No. III-5; (f) Stover et al. 1973, IEEE Int. Solid State Circuits Conf. Dig. Philadelphia; (g) Whelehan et al. 1973, Microwave J., 16 (11), 35; (h) Chiao and Parrish. 1976, J. Appl. Phys., 47, 2639; (i) Taur et al. 1974, IEEE Trans. Microw. Theory Techn., 22, 1005; (j) Edrich. June 1976, IEEE-MTT Int. Microw. Symp. (late paper); (k) Phillips and Jefferts. 1974, IEEE Trans. Microw. Theory Techn., 22, 1290; (l) Kerr. 1975, IEEE Trans. Microw. Theory Techn., 23, 781.) Up to the present the Schottky-barrier mixer is the most widely employed receiver type, although increasing emphasis is now being placed on other cryogenic receivers.

Millimeter Telescope Projects

Reports on recent projects are summarized below. Each contribution is identified by the university or institute involved, and features of the antennas are listed in Table 2.

TABLE 2. RECENT MILLIMETER TELESCOPE PROJECTS

Group (country)	Site (altitude)	Diameter	RMS accuracy	Status	Other Information
NRAO (U.S.A.)	(undecided)	25 m	.075 mm	early planning	in radome
MPG (Germany) &	South Spain (3300 m)	30 m	<.1 mm	under design	joint MPG/INAG institute in Grenoble; early 1980's;
INAG (France)	S. of Grenoble (2550 m)	4 x 10 m	.1 mm	under design	French project is four element synthesis array
Caltech (U.S.A.)	Owens Valley (1200 m)	10 m	.07 mm	built	several 10 m dishes for interferometer planned
U. of Mass. (U.S.A.)	5 College Obs. (306 m)	13.7 m	.11 mm	built	in radome
CSIRO (Australia)	Parkes (392 m)	16.7 m	.27 mm	operating	center of 64 m dish
	" "	37 m	.8 mm	"	" " " " "
	Epping	4 m	.1 mm	built	2 m dish being built for interferometry
	Tidbinbilla	64 m	-	operating	NASA Deep Space Station; has operated at 13 mm
Chalmers (Sweden)	Onsala (14 m)	20.1 m	.2 mm	operating	in radome
Bell Labs (U.S.A.)	New Jersey (90 m)	7 m	.1 mm	built	off-axis parabolic surface
U. C. Berkeley (U.S.A.)	Hat Creek (1050 m)	2 x 6 m	(1 mm)*	operating	synthesis array, 2 elements

*quoted wavelength limit

National Radio Astronomy Observatory (B. E. Turner) The plan is to erect a homologous dish in a dome with a slit. At 0.8 mm the telescope would have an 8" arc beam and a 15% aperture efficiency. The total cost would be $8 million and though no site has been chosen, Hawaii is a possibility.

Max-Planck-Institut für Radioastronomie (J. W. M. Baars) This part of the Franco-German project (CNRS-MPG, see below) will place a homologous dish on a mountain 55 km from Granada. A joint institute for operating the two observatories is planned in Grenoble. The estimated cost of the 30 m telescope alone is DM 17 million.

California Institute of Technology (M. S. Ewing) In a project headed by R. B. Leighton a prototype 10.4m f/0.4 reflector has been built whose aluminum honeycomb panels have been machined in place on the backup structure and surfaced with sheet aluminum. An improved mirror is under construction and a reflector with 15 μm errors appears possible. Three improved reflectors will be used for interferometry in Owens Valley, while a specially treated antenna is to be built for high altitude submillimeter observations.

Institut National d'Astronomie et de Geophysique (E. J. Blum) The proposed synthesis array consisting of four dishes on a T-shaped baseline 2 km (EW) x 1 km (NS) will operate between 22 GHz and 150 GHz. It will be possible to synthesize a field of 1'arc in less than a week with 3"arc resolution, and the maximum resolution will be 0"5 arc (at 115 GHz). Studies have begun to develop cooled mixer R.F. heads and an oversized waveguide transmission system linking the antennas. This project is part of a French-German proposal (CNRS-MPG) for a millimeter facility.

University of Massachusetts (W. M. Irvine) Initial tests of the telescope system are planned for the autumn of 1976. The 1024 channel digital autocorrelator has a bandwidth of 25-30 MHz (50-60 MHz for 512 channels with bandwidth doubling). The computer system, based on a Mod Comp IV/25, enables almost complete data reduction at the telescope. Receivers include a ruby travelling wave maser (f = 20-25 GHz, Δf = 30 MHz, T_S = 50-100 K), with a rutile TWM (85-95 GHz, 140 MHz, 100 K), state of the art mixers at 2 and 3 mm and a 115 GHz rutile maser planned.

Australian projects, CSIRO (B. J. Robinson) The 16.7 m reflector, using cooled mixer receivers, has surveyed CS ($J=1\rightarrow0$, 48 GHz) emission in the southern Milky Way, and searched for SiO masers at 43 GHz. The 4 m dish will survey CO, HCN, HCO^+, etc., in the Galaxy and Magellanic Clouds. An 80-120 GHz cooled mixer receiver and 512 channel "electro-acoustic spectrograph" are under development. An interferometer (4m and 2m dishes) with baselines up to 100 m is under construction.

Chalmers University (B. Höglund) The 20 m Cassegrain dish has a tracking accuracy of 2" to 3" arc. At present there is a 100 K maser available for the 21 to 25 GHz band, with a 29 to 35 GHz maser planned for the near future. An 88 to 115 GHz uncooled mixer will soon be available and there are plans for a cooled mixer. Spectrometers are being developed for line observations.

Bell Laboratories (R. W. Wilson) The reflector is a 7 m circular section of a 16 m diameter parabolic surface. This permits the operation of an offset Cassegrain system with no aperture blockage. The initial astronomical receiver will cover 70 to 150 GHz and have two 256 channel spectrometers of 0.25 and 1 MHz resolution.

University of California at Berkeley (J. Welch) The interferometer is designed for operation between 1 mm and 15 mm. The two dishes can be moved along a 'T' shaped rail line 300 m EW by 200 m NS. For the 11 mm to 15 mm wavelength range the sensitivity after a full synthesis is 10 mJy.

II. INTERSTELLAR RADIO SPECTROSCOPY

During this session, chaired by T. L. Wilson, the following papers were presented:

Radio Recombination Lines (M.J. Seaton)

Molecular Line Excitation: The Density and Mass of Molecular Hydrogen Clouds in the Galaxy (P. Solomon)

Radial Gradients in Isotopes and Elements (M. Walmsley)

Galactic OH towards extragalactic radio sources (I. Kazès)

Radio recombination lines at 300 MHz (A. Parrish)

Spatial extent and gas motions in the ρ Oph. dark cloud (P. Myers)

Interstellar HC_5N in a dark cloud (J. MacLead)

Recombination line broadening (P. Encrenaz)

1 September 1976

Two scientific sessions and an extra business meeting were held on Wednesday, 1 September.

I. MORNING SCIENTIFIC SESSION

In the meeting, chaired by H. van der Laan, the following papers were presented:

Hard- and Software

Progress report on the VLA (D. S. Heeschen)

Data processing for synthesis arrays (W. N. Brouw)

Theoretical analysis of CLEAN (U. J. Schwarz)

Nearby Extragalactic Systems

Introductory review (W. K. Huchtmeier)

Line and continuum studies of edge-on galaxies (R. Sancisi)

Nearby spirals (J. H. Oort)

CO in external galaxies (B. M. Zuckerman)

Neutral hydrogen in the far south of M31 (R. D. Davies)

Gas motions in the M81/M82 group from HI observations (L. Weliachew)

HI observations of NGC3077/M81 and NGC4038/39 (J. M. van der Hulst)

HI warps in M31 and M33 (D. Emerson)

Warps and bar-like disturbances in galaxies (A. Bosma)

The peculiar galaxy NGC3718 in HI (U. J. Schwarz)

Radio continuum studies of IC342 (R. Wielebinski)

The radial distribution of various constituents in M31, M33 and the Galaxy (E. M. Berkhuijsen)

Radio maps of NGC3310 and 3079 at 2.7 and 8.1 GHz (E. R. Seaquist)

II. AFTERNOON SCIENTIFIC SESSION

The chairman, J. R. Shakeshaft, introduced the following papers:

The Stereo I experiment for type I radio bursts (J. L. Bougeret)

The proper motion of the Crab pulsar (S. Wyckoff)

The origin of Loop I and its relation to the local gas (H. Weaver)

Stimulated recombination line emission from M82 (P. A. Shaver)

Radio Galaxies, their Nuclei and Quasars

Preliminary results from the 151 MHz synthesis array at Cambridge (P.F. Scott)

Fifteen southern radio galaxies mapped with the Fleurs Synthesis Radio Telescope (W. N. Christiansen)

Brightness distributions from VLBI data, using closure phase (P. Wilkinson and A. Readhead)

High resolution observations of M81, M82 and the galactic center (K. Kellermann)

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NRAO 150, the smallest angular size radio source; and other VLBI results (D. Shaffer)

VLBI observations of the radio nuclei in extended radio sources (I. Pauliny-Toth)

The rôle of central components in extended radio sources (T. K. Menon)

The complete polarization properties of compact radio sources (R. S. Booth)

The spectra of radio source variations at meter - wavelengths (W. Erickson)

The radio spectral evolution of some quasars (W. Dent)

Appeal for flux density data on 3C454.3 (J. Wardle)

Optical spectra of radio galaxies - Lick spectrophotometric observations (R. Costero)

III. EXTRA BUSINESS MEETING

About sixty members were present when the chairman, H. van der Laan, opened the meeting. One point was on the agenda, the reorientation of Commission 40. The chairman stated his case for changes in the Commission's activities and its relation to other Commissions of the IAU (this and the ensuing discussion are summarized here as succintly as possible).

The Chairman's Statement

(a) Commission 40 is both a very large and a very active component of the IAU. Rumors of its abolition are so unrealistic that they must be dismissed as frivolous.

(b) Radio astronomy is now a mature constituent of modern astronomy regarded in its spectral dimension. As such radio astronomy touches upon virtually every subject in astrophysics and observes practically every category of astronomical object. This implies that those who use radio telescopes, i.e. usually members of Commission 40, normally have interests in one or more other Commissions whose activities and goals are circumscribed by astrophysical themes or astronomical objects. All Commission 40 members must therefore be emphatically encouraged to join and participate actively in the Commission(s) where their astronomical interests are developed.

(c) Radio astronomical observations using established techniques should be integrated and analysed in the best astrophysical context. Such research should therefore be reported in the astronomically most appropriate commissions and those commissions should in their meetings and written reports take cognizance of and fully profit from these investigations. Commission 40 should discontinue publishing all and sundry subjects in its triennial Reports in Astronomy and instead encourage and assist other commissions to integrate radio astronomical results in their reviews.

(d) Radio observatories are very vulnerable to terrestrial and space interference. Radio astronomers must be constantly vigilant to protect essential frequency intervals of the radio spectrum. They can do so effectively only by a concerted global effort. For this effort the activities of Commission 40 are indispensable. Commission G of URSI and Commission 40 of the IAU together can provide the network of relations which IUCAF requires for frequency protection.

(e) Astronomical applications of radio techniques continue to be developed. In the R & D stage of new devices and methods Commission 40 provides the best context for astronomers to exchange and compare experience in this area of astronomical techniques.

(f) Radio astronomers frequently engage in joint programs (e.g. monitoring variable sources) and complex multinational cooperative arrangements. Commission 40 can provide organizational and moral support.

Under (b) and (c) the chairman's views of how Commission 40 ought to reorient are stated, while under (d), (e) and (f) important reasons for continued Commission 40 activities are given.

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Discussion

Several members proposed that an additional reason for Commission 40's continued existence is the 'bond of kinship' among radio astronomers. There is no justification for disregarding history and disowning the enjoyment of sharing in this development and communicating in a common jargon, even though this concerns a great variety of astronomical interests. Some members appear not to be a member of any other Commission at all, but most of those in attendance agreed that Commission 40 cannot be expected to cover even a fraction of the astronomical research carried out by radio astronomical techniques. The meeting therefore strongly supported the chairman's proposal that each member join other Commissions to represent his interests as well. For solar astronomers especially this appears to be of vital importance if their research is to gain the attention it deserves in solar physics.

Commission 40 members who are on the IAU Executive Committee are encouraged to make it crystal clear in the Executive that Commission 40 remains a strong and active Commission, which sees many excellent reasons for its existence and which has no intention whatsoever of being abolished. A motion to this effect was passed by acclamation. The meeting ended with a discussion concerning the Commission's activities at General Assemblies. Many members said they enjoyed the meetings which were organized in Grenoble on the spot and which dealt with many subjects, mainly extragalactic, but where due to the common language and the general supposition that techniques used were already understood, a very great information rate was achieved. These members felt that in the future such meetings, of many short contributions, should be held again. Others thought it a pity that beautiful results obtained at radio observatories should in their presentation be confined to Commission 40 meetings and strongly urged that these results be aired at the meetings of other Commissions. The conclusion was that in the future the Organizing Committee of the Commission should, in preparation for the General Assembly, organize as many joint discussions and multiple Commission meetings as is feasible, to assure a proper forum for radio investigations. The chairman appealed to Commission members to support its Organizing Committee by responding positively when requested to contribute. He promised to do what is necessary to organize Commission 40 work in preparation for the 1979 General Assembly in the spirit of this discussion.

COMMISSION 41: HISTORY OF ASTRONOMY (HISTOIRE DE L'ASTRONOMIE)

Report of Meetings, 30, 31 August 1976

PRESIDENT: O. Gingerich SECRETARY: M. Hoskin

30 August 1976

I. BUSINESS SESSION

Members stood for a few moments to honor the memory of the late Dr. Per Collinder, and then elected J. Dobrzycki (Poland) as President, M. A. Hoskin (UK) as Vice-President, and S. M. R. Ansari (India), W. Hartner (GFR), P. G. Kulikovsky (USSR) and O. Gingerich (USA) as members of the Organizing Committee together with O. Pedersen (Denmark) as representative of International Union of the History and Philosophy of Science. The president expressed his gratification that a large number of former consulting members of Commission 41 had now been nominated for full membership of the IAU by their respective national committees: Z. Horsky, H. D. Howse, J. North, R. Taton, V. Thoren, and J. P. Verdet. Other new members of the Commission include D. Heggie, G. Jackisch, G. S. Khromov, K. Lang, J. Merleau-Ponty, J. Rybka, and W. Sullivan. It was then resolved that "The members of Commission 41 wish to thank our Soviet Colleagues for their regular publication of *Bibliography of Books and Papers Published in the History of Astronomy*, and urge the continued publication of this valuable aid to research", and that "The members of Commission 41 recommend to the General Secretary that this *Bibliography* be listed as an official IAU Publication".

M. A. Hoskin then reported on the progress of the *General History of Astronomy*. Contracts had been signed with Cambridge University Press for publication of the work in four volumes of about 600 pages each. The volumes would appear separately, and it was hoped volume 3 would be ready for the printer early in 1978; authors for all four volumes were now being commissioned. The presence of every volume editor at Grenoble would allow the editorial board to meet and settle the remaining questions of general strategy.

II. OBSERVATIONS IN ANCIENT AND MEDIEVAL ASTRONOMY.

R. R. Newton, in a series of books and articles, has compared the available reports of various astronomical observations, from the eighth century B. C. to the thirteenth century A. D., with the results expected on the basis of modern astronomy. He came to distrust the authenticity of many of the alleged observational data from Ptolemy's *Almagest*, reaching the general conclusion that Ptolemy was the fudger of observations *par excellence*. In a review paper on the role of observations in ancient and medieval astronomy, W. Hartner agreed that some of Ptolemy's "observations" were actually calculations, but explained that it was historically anachronistic to label the Alexandrian astronomer's work fraudulent. Hartner then presented a far-ranging discussion of the relationship of observation to theory in the astronomy of Greek Antiquity, China, Islam, and the Renaissance.

K. P. Moesgaard described a specific and technical study of "Hipparchus's Solar Theory Derived from Lunar Eclipse Observations." To save the lunar eclipse phenonomena, Ptolemy by and large adopted the entire Hipparchian model machinery which, after three hundred years, still worked perfectly. Ptolemy stuck to an apparent mess of really good and very faulty parameters handed down from his predecessors, but one cannot simply characterize his behaviour as fudging. He may well have had good reasons for his attempt at preserving the continuity with earlier astronomy.

Hartner's contribution will be published in full in the February 1977 *Journal for the History of Astronomy (JHA)*, and an extended summary of Moesgaard's paper appears in *JHA* 7, 216-17, 1976.

Shorter papers were given by F. Link on the role of ancient observations in establishing the solar cycle, and by R. Movahed on recent excavations of the old Maragha Observatory in Iran.

III. RETIRING PRESIDENTIAL ADDRESS

O. Gingerich reviewed some recent research on Copernicus and in particular his interpretation of the Tycho documents he had discovered in the Vatican Library in 1973. The most interesting of these manuscript pages from 1578 (illustrated in the IAU *Highlights in Astronomy* 1973) shows a proto-Tychonic system in which the Sun carries Mercury and Venus around the central Earth, but in which the superior planets retain Ptolemaic epicycles. Tycho did not formulate his own system until five years later, and his hesitation resulted from his belief in the crystalline spheres; had he placed Mars in orbit about the Sun, it would have cut the orbit of the Sun about the fixed Earth, yielding a mechanically unacceptable system. By 1583 Tycho was willing to adopt this arrangement and abandon the crystal spheres. N. Swerdlow had suggested on the basis of a page in the so-called "Uppsala notebook" that Copernicus at one time considered a geocentric Tychonic system. Gingerich argued that the parallel evolution of Tycho's own cosmology supports the view that Copernicus was driven to a heliocentric system in order to retain simultaneously the crystalline spheres and the unity of an orbital system surrounding the Sun.

IV. PRESERVATION OF TWENTIETH-CENTURY ASTRONOMY

This session, occupying the whole Monday afternoon, was devoted to the question of what records of contemporary astronomy should be preserved for future historians. In the opening paper. M. A. Hoskin showed by example how complete a record of the "intellectual biography" of a problem in astronomy could be available from as recently as the 1920s. The two traditional interests of the historian--intellectual biography and the impact of instrumental changes--would always be of central importance, but today other questions had gained in significance, and sources must be preserved to enable the historian to investigate these questions also. They included: the action of grant-giving agencies, the dynamics of particular observatory groups, the intellectual networks on an international scale, the identification of indicators of scientific activity, and the development of instrumentation.

The records on which answers might be based included written documents and "oral history." Hoskin briefly illustrated some of the dangers of oral history, before directing his attention to problems of preserving written records. Documents occupy space and space is expensive; they are of use only if the historian can locate them, and the preparation of catalogues is expensive; much modern paper is made from highly-acidic wood pulp and will need costly lamination if it is to survive many decades, together with preservation in stable conditions with relative humidity low enough to prevent the multiplication of spores; and historians must be given access to documents under (expensive) supervision. The preservation of archives is therefore a costly business, and historians must bear this in mind when advocating the nature, and the scale, of records to be kept.

Commenting, S. Weart described the experiences of the staff of the Center for History and Philosophy of Physics of the American Institute of Physics in the collection of oral history, and discussed some of the problems involved in preserving the history of very large (governmental) scientific organizations. S. M. R. Ansari outlined the contrasting situation in India, where the tendency was towards autonomous observatories; and O. Pedersen announced the deposit of the Hertzsprung papers in the Institute for History of Science at Aarhus University.

Two senior astronomers then discussed problems that had arisen in their own experience. B. Strömgren listed a number of possible research problems in history of astronomy in the last half-century, and emphasized the special importance of establishing the input from physics into a given astronomical problem area. W. H. McCrea drew attention to the influence of referees' reports and, more generally, to the impact of editorial decisions.

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31 August 1976

V. MEGALITHIC ASTRONOMY: FACT OR SPECULATION?

The Tuesday morning session drew an audience so large that some were unable even to find standing room in the lecture hall. D. C. Heggie opened with a review paper on "good" and "bad" evidence, well illustrated with colored slides of megalithic sites in Britain. What is difficult to decide about almost all orientations is whether they were deliberately incorporated by the people who built the monuments, or whether they occur quite by chance; and, if they were deliberate, why was it done? Heggie's analysis opened with structural considerations. For example, some types of orientation are impractical. Tomb passages are one, and those involving the centers of stone circles are another, for the centers are not often marked. Turning to astronomical evidence, he pointed out that even when one knows of megalithic orientations to the astronomically significant points on the horizon, there remains the possibility that they occur by chance. This is what is meant by "bad" evidence: it is evidence quite consistent with the view that the megalith-builders did not deliberately incorporate astronomical orientations. For a long time, almost all of the evidence on megalithic astronmy was bad evidence, and thanks are due mainly to A. Thom for the fact that this situation has changed.

Even if one is persuaded that megalithic orientations were deliberately astronomical, it remains to be seen what purpose they served. The most popular theory for solar lines is a calendrical one. The difficulty with this explanation is the abundance of solstitial lines; for the very reason that solstitial lines are easy to set up, they are difficult to use for the determination of the time of the solstice. On the other hand, one would *guess* that solstitial lines would play a central role if the purpose of the orientations was religious. Lunar orientations are usually discussed in the context of eclipse predictions. Thom's method requires the use of orientations of comparatively high accuracy, in order that solar perturbations could have been detected. However, the absence of entirely satisfactory evidence for accurate orientations combine with astronomical and archaeological difficulties to make this theory unattractive. Even Hawkins's method (or Hoyle's modification of it) is unnecessarily involved. (To say that Stonehenge was a computer is to say in essence that it was used to facilitate the the counting.)

An extensive summary of Heggie's paper is found in *JHA* 7, 220-222, 1976.

In his commentary, O. Pedersen remarked that so little is known of Stone Age religion that to call the monuments religious rather than astronomical is to beg the question. He himself held on the present evidence that the builders of simple monuments had *some* astronomical ideas in mind, even if these were subordinate to (say) religious ones. Pedersen also warned against the transfer of credibility (as when D. G. Kendall's support for the megalithic yard had swung sentiment in favor of Thom's *astronomical* thesis, despite Kendall's own disclaimer).

J. Dobrzycki, in examining the difficulties of a hypothetical megalithic observer from the viewpoint of modern astronomical knowledge, cast doubt on the reasonability of highly accurate alignments, for example, for lunar extrema. In the discussion from the floor, F. Biraud, appealed for support for a campaign to protect megalithic remains in France from the destruction now going on. The session concluded with an account by J. Eddy of his studies of the solstitial and stellar alignments of Big Horn Medicine Wheel in Wyoming and newly investigated similar sites of the Plains Indians in Canada and the USA. Eddy's beautifully illustrated and fascinatingly recounted report were enthusiastically received by the large audience.

VI. RARE BOOKS IN ASTRONOMICAL LIBRARIES

In the final session, held jointly with Commission 5 (Documentation), a number of speakers outlined the history and holdings of the principal collections

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of rare books now in observatory libraries. An introductory paper by M. Conti-Grassi (and read by G. Feuillebois) described her census of 16th-century books in observatory collections. Contributions were given concerning the Paris Observatory (G. Feuillebois), the Crawford Collection at the Royal Observatory in Edinburgh (M. Smyth and E. Forbes, read by M. Smyth), the Uppsala University Observatory (N. Olander), and the Spanish Naval Observatory in San Fernando (D. Almorza, read by J. Benavente). In addition, O. Gingerich reported on his survey of Copernicus *De revolutionibus*; he has located 230 copies of both the 1543 Nuremburg edition and the 1566 Basel edition, and has personally examined approximately 180 copies of each edition.

VII. CONSULTING MEMBERS OF COMMISSION 41

This commission differs from most in the comparatively large number of consulting members, almost all of whom are professional historians of science working on the history of astronomy or instrumentation. Those currently appointed are: A. Aaboe, J. A. Bennett, M. L. Righini Bonelli, B. R. Goldstein, D. B. Herrmann, E. S. Kennedy, D. A. King, H.-G. Körber, P. Kunitzsch, H. Labat, F. Maddison, Y. Maeyama, K. P. Moesgaard, J. Needham, N. I. Nevskaja, D. Pingree, E. Poulle, D. J. de Solla Price, T. Przypkowski, B. A. Rosenfeld, G. Rosinska, H. Sandblad, Z. Sokolovskaya, F. R. Stephenson, N. Swerdlow, R. Taton, G. J. Toomer, B. E. Tumanjan, A. Van Helden, J. Vernet Ginés, B. L. van der Waerden, D. W. Waters, S. Weart, R. S. Westman, D. T. Whiteside, and C. Wilson.

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COMMISSION 42: CLOSE BINARY STARS (ÉTOILES BINAIRES SERRÉES)

Report of the Meetings August 25, 28 and September 1, 1976

PRESIDENT: T. J. Herczeg SECRETARY: D. B. Wood

Commission 42 convened for two business meetings and two scientific sessions. In the following, the minutes of the business meetings and a summary of the scientific meetings are presented, with the abstracts of some of the papers read.

Business Meeting I - August 25, 1976

The President called the meeting to order at 0910, and outlined the following schedule of events which was agreed to by the attendees: (1) Triannual history; (2) nomination and election of officers and new members; (3) future meetings; (4) coordinated programs, information systems; (5) scientific priorities.

1. Triannual History

Herczeg indicated that the Report of the Commission did exist, but that it was unavailable for the commission members to comment on. The work on X-ray binaries attracted particular interest during the last three years. Three major developments were Symposium No. 73 (Cambridge), the Greenbelt conference, and the X-ray-optical coordinated observing programs.

The group extended a vote of confidence and thanks to Dr. Larsson-Leander for his very important "Bibliography and Program Notes" and also to Dr. Szeidl for reporting much of the current work on eclipsing binaries in the IBVS of Commission 27.

2. Nomination and Election of Officers and New Members

The Organizing Committee (OC) has proposed for the 1976-79 triennium for President,

G. Larsson-Leander;

for Vice President,

B. Warner.

The OC further proposed the addition of Dr. Kondo and Dr. Whelan to the Committee while Herczeg reported that Dr. F. B. Wood intended to resign from his membership in the OC to make room for younger astronomers.

In addition, the National Committees have proposed Dr. Kruszewski (Poland) and Dr. Cherepashchuk (USSR); further, Herczeg proposed Dr. Sinvhal. It was found that there was good reason to add Cherepashchuk to represent research in the Soviet Union; since research in Poland is already represented by Smak, an addition from this country may not be necessary; Sinvhal would add to the representation of the rapidly growing astronomical work in India.

To Dr. Wood, the group expressed their gratitude for his service which dates to the beginning to Commission 42.

Since Plavec and Popper both are at UCLA, they each offered to resign to make for room on the OC. Popper prevailed in tendering his resignation, and the group expressed their thanks for his service.

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Plavec expressed his concern for the lack of a "classical photometrist" on the OC. Herczeg pointed out that four members of the proposed OC do photometric work on a fairly regular basis.

The slate was then unanimously accepted by the Commission members.

Note that the final Membership of the OC is as follows:
Batten,* Charepashchuk, Fracastoro, Gyldenkerne, Herczeg, Kitamura, Kondo, Plavec, Sinvhal, Smak, van den Heuvel, Whelan.

F. B. Wood expressed his concern that the Commission go on record that National Committee recommendations will always be taken under advisement by the Commission but that we are in no way bound to accept them.

The following new members to the Commission were proposed:

By the OC: Anderson, Bath, Brownlee, Faulkner, Gursky, Geyer, Hazlehurst, Hilditch, Krezminski, Lucy, Scarfe, Seggewiss.

By the respective National Committees: Breinhorst, Budding, Harmanec, Rovithis, Semeniuk, Schoeffel.

By Commission Members: Chambliss, Rahe, van'tVeer, Ziólkowsky.

Smak expressed his view that it would be important to know more about the proposed new members in advance of the meeting. The following formal proposal, as a reminder, was approved unanimously:

"For further additions to the Commission, it is desired that the OC be ready to support each proposed member".

Herczeg read a letter of resignation from Commission 42 from Dr. A. J. W.Cousins, as he ceased to be active in the field of eclipsing binaries.

The new Commission members were then all admitted as a group.

3. Future Meetings

Possible future meetings were discussed. IAU-Colloquium No. 42, to be held in Bamberg (September 1977), already approved by the Executive Committee, was announced. Specific attention has been paid to a proposal by Czech astronomers (conference on emission line objects) and by astronomers from New Zealand (conference on duplicity among intrinsic variable stars). Decision about possible co-sponsoring by Commission 42 was postponed until the 2nd business meeting. However, the following formal proposal by Plavec was approved unanimously:

"Commission 42 proposes and is ready to sponsor a conference on close binaries, patterned after the highly successful Parkesville or Cambridge conferences, to be held in 1979 in conjunction with the IAU General Assembly".

*Dr. Batten's name was omitted inadvertently from the original list, and has been added here as approved at Session II.

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4a. Coordinated Programs

X-ray and optical coordinated programs for Cyg X-1, Her X-1, 3U0900-40, and 3U1700-37 were discussed. Bolton commented on the problems of scheduling satellite time for the X-ray observations. Kondo suggested extending the list to include Cyg X-2 and other objects.

The first business meeting ended at 1035.

Business Meeting II - September 1, 1976

The President called the meeting to order at 0905. It was pointed out that those who wish to become Commission members should contact Larsson-Leander.

4a. Coordinated Programs (continued)

Kondo and Bolton reported on their recent efforts concerning cooperative X-ray and optical programs. The UK-5 satellite will be available for such programs, and efforts are being made to use SAS-3 and OSO-8.

Herczeg expressed interest in "revitalizing" the two pertinent subcommittees: Coordinated Program Subcommittee (Glydenkerne), and Extraterrestrial Observations (Kondo).

It was suggested to retain all four objects, Cyg X-1, Her X-1, 3U0900-40 and 3U1700-37, on the coordinated X-ray and optical program. If other stars are of interest, the Subcommittee on Extraterrestrial Observations should initiate the effort, through the Subcommittee on Coordinated Programs.

The Commission recommended coordinated optical programs on RX Cas (for two years, as proposed by Dr. Martynow acting as coordinator) and on VV Cep (proposed to the OC by Dr. A. Galatola).

Dr. Gibson reported on the coordinated radio and optical program on RS CVn variables. At the present, he is organizing a temporary working group, which will probably eventually be headed by D. Hill.

The above set of coordinated programs was unanimously approved.

There was some discussion concerning earlier programs for Y Cyg (O'Connell) and for AR Cas (Herczeg).

3. Future Meetings (continued)

The OC suggested postponing final position on the conferences put forward on emission line objects and duplicity, as mentioned in Session I under pt. 3. In the ensuing discussion the opinion prevailed that the Commission saw itself unable to co-sponsor these meetings at the present time.

It was proposed, and carried, to support (jointly sponsor) an upcoming colloquium in Victoria B.C. in the fall of 1977 on Of and OB stars, as proposed to the Executive Committee by Drs. Swings, Conti and others.

There was more discussion regarding a symposium on close binaries in conjunction with the next IAU General Assembly. (See Session I, pt. 3.) Cooperations should be sought from Commissions 29, 35 and 44. A likely site could be Toronto, Calgary or Montreal. Smak proposed that we formally propose very strong support of such a symposium. It was unanimously voted to do so, and a nucleus of an organizing committee was named, consisting of Plavec, Batten and Larsson-Leander.

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There was some discussion regarding the inclusion of radio astronomers. Bolton noted that Commission 40 was planning a meeting on radio stars, including binaries.

4b. Information Systems

Herczeg introduced the topic of information sources, namely data repositories, catalogs, and published data. For binary star researchers, the basic catalogs are the Moscow General Catalog of Variable Stars, Batten's Catalog of Spectroscopic Binaries, and the Finding List for Observers of Eclipsing Binaries.

Batten reported on the status of the 7th edition of his catalog. He noted the problem of obtaining V magnitudes for variables stars. It is clear that observers should be encouraged to at least provide the V magnitude of their comparison stars. F. B. Wood reported on his card catalog of eclipsing binary publications, and asked if another edition of the Finding List would be useful. The Commission voted unanimously to support the publication of such a revised Finding List.

Data repositories are maintained by the RAS and by Odessa Observatory, but there is no catalog of what systems are in these repositories. Apparently little data is actually in them (less than 50 systems); observers should be encouraged to send their data. It was proposed that Commission 42 should contact the Editor of the IBVS to publish a list of systems in the repositories.

5. Priorities of Research

Basically, the priorities have not changed since the last General Assembly. Herczeg proposed that we support the same priorities, but with increased emphasis on X-ray and radio studies, and dropping reference to work with the intensity interferometer. The Commission members voted to accept that proposal.

The business meeting was adjourned at 1050.

Scientific Sessions

The main scientific session of Commission 42 was held on August 28 under the title "Current Trends in Binary Star Research" and continued on September 1 under the title "Short Scientific Meeting". The following summary covers both sessions. The intention was to give in these meetings a fair cross-section of the present work on close binaries, with the possible exception of the X-ray binaries (which formed the topic of a Joint Discussion with Commissions 44 and 48).

Seven review papers (invited) and 16 short reports were presented; for 13 of these contributions the abstracts are given below.

Among the invited papers were J. Smak, disk-structures and the outbursts of dwarf novae; M. Plavec dealt with mass transfer and Be stars; D. M. Popper reviewed binaries with H and K emission; A. H. Batten presented recent spectroscopic studies of circumstellar matter considering, in particular, the systems U Cep and RZ Oph. Anne P. Cowley reviewed the VV Cep-type systems, with emphasis on the recent eclipse of AZ Cas; she pointed out that all these systems exhibit high eccentricities which circumstance may play an important role in their particular evolution. (Two further papers, by K. O. Wright and R. Faraggiana, dealt with the system VV Cep itself, now approaching eclipse.) D. B. Wood reviewed the light-curve synthesis methods in calculating eclipsing binary orbits and Y. Kondo reported on his and G. McCluskey's studies of mass flow in early type close binaries, based on UV observations.

G. S. Mumford gave a short discussion of the period of U Gem and J. Ziółkowski presented his interpretation of the relationship between Algol-type systems and

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X-ray binaries. J. Anderson commented on the accuracy of mass and radius estimates from binary systems; T. B. Horak reported on a five-colour photometry of HO Tel and RW CrA done in collaboration with C. J. van Houten and J. Grygar.

D. Y. Martynov gave a detailed description of the remarkable system RX Cas, proposed and accepted for a coordinated program. This 32-day eclipsing system consists of two evolved components (G3III + A5IIIe) with strongly variable light curve and many indications of a strange spectroscopic behaviour. In a short report, Anne P. Cowley informed the Commission that the X-ray source 3U1809+50 has quite recently been identified with the (irregular) variable AM Her which also was found to be a short period spectroscopic binary.

Abstracts of Papers

The following abstracts are arranged in a topical order: observational techniques, radio astronomy of binary stars, early-type systems and binaries with emission lines, special systems, numerical solutions. For reasons of limited space, in a few cases the abstracts have been slightly shortened here.

The Systematics of Visible-band Linear Polarization for Close Binaries (R. H. Koch, U. Pennsylvania).

If cool contact, flare, and degenerate systems are excluded from consideration, there now exist some 1500 filtered and almost 1000 unfiltered linear polarization measures distributed among 63 close binaries. With this quantity of data, it is possible to assess the incidence of intrinsic polarization as a function of binary evolution.

No single stellar characteristic--e.g. rotation, mass, mass ratio--is sufficient to predict if a binary will or will not be intrinsically polarized. It is convenient, however, to parameterize the polarization in terms of the separation between the photospheres of the component stars.

Among unevolved binaries, intrinsic polarization is rare, presumably indicating the lack of efficient scattering envelopes. At present, the only convincing exception to this generality is U Oph, which is known to be photometrically complicated. For evolved binaries, intrinsic polarization is widespread. It is uncommon only if the two stars are very close together in linear units and this is partly due to the finite precision of present measures. Typically because of stream, disk, shell, and envelope scattering--but not because of photospheric scattering--polarization is common among relatively wide pairs.

There exist about 1000 filtered measures for some 20 contact pairs between B5 and K1. Most of these data are not yet analyzed, but certain systems show variations of the orientation of the electric vector reminiscent of the calculations by Collins and Buerger.

Variable Polarization in U Cephei (V. Piirola, Helsinki).

Large increase in linear polarization of U Cep was observed during the primary minimum on 1975 Sept. 8 and confirmed during several minima from Sept. 1975 to April 1976. Typically, the polarization increased from 0.10 percent after first contact to 0.80-1.08 percent near second contact (beginning of totality), then decreased towards mid-eclipse close to 0.10 percent and increased again near third contact (end of totality) to 0.80-1.04 percent. The maximum value of polarization varied from cycle to cycle and decreased towards the spring 1976 to about 0.50 per cent. Sometimes the increase near second contact was small. Mean polarization

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outside eclipses was 0.17 ± 0.03 percent. Position angle was close to 95° except near second contact where it changed to about 60°.

The changes in the polarization of U Cep could be explained by circumstellar matter surrounding the primary. Polarimetric observations correlate with the spectroscopic observations and give further evidence and information about changes in mass transfer and amount of circumstellar matter in U Cep.

Microwave Emission from RS CVn Binaries (D. M. Gibson, Manchester).

Surveys of some 30 known RS CVn binaries at centimeter wavelengths with telescopes at the NRAO and Jodrell Bank have resulted in the detections of AR Lac, UX Ari, RT Lac, HR 1099, RZ Eri, and λ And, and the probable detection of PW Her. Subsequent monitoring of these systems at the NRAO, Jodrell Bank, Cambridge, and Algonquin Radio Observatory have shown them to be variable on a timescale of $\sim$1 day with luminosities as large as 6×10^{17} ergs s^{-1} Hz^{-1} at 8085 MHz. The observed behaviour is consistent with recurring outbursts where large outbursts are exponentially less probable than small ones. Statistical considerations make it probable that the RS CVn systems as a class are the first optically-selected class of stellar microwave radio-emitters.

Analyses of ten large ($L_{8085\ MHz} > 6\times10^{16}$ ergs s^{-1} Hz^{-1}) outbursts from AR Lac, UX Ari, RT Lac, and HR 1099 permit the unique determination of the source parameters during extremes of the observed behaviour. The evolution of the source spectrum during an outburst from optically thick to optically thin and the presence of circular polarization clearly indicate the radiation mechanism is gyrosynchrotron emission from a power law distribution ($\Gamma \sim 2$) of mildly relativistic electrons in magnetic fields $B_\perp \sim 30$ Gauss. These properties allow independent calculations of the brightness temperature $T_B \sim 10^{10}$K, and, thus, the source size $R \sim 10^{11}$ cm. The total energy in fields and particles during such an outburst can be as large as 10^{36} ergs.

Radio Emission from AG Pegasi (P. C. Gregory and S. Kwok, U. British Columbia, E. R. Seaquist, David Dunlap Obs.)

Radio emission from the symbiotic nova AG Pegasi has been detected at 2.8 and 3.7 cm and an upper limit obtained at 11 cm. The observations are interpreted as free-free emission from an ionized nebula formed by continuous mass ejection from the WN6 star. Our observations indicate a mass loss rate of 10^{-6} $M_\odot$/yr and a total mass for the nebula of 7×10^{-5} $M_\odot$.

Recent Ultraviolet Observations of the Mass Flow in Close Binaries (Y. Kondo, NASA Johnson Space Center, G. E. McCluskey, Lehigh U.)

The ultraviolet spectrum of the eclipsing binary UW CMa (07f + 0-B) has been observed with the Copernicus Princeton University Telescope Spectrometer in the wavelength region 950-1560 Å at a resolution corresponding to 0.2 Å. These observations were obtained near phases 0.25 and 0.75 to investigate the presence or the absence of the orbital Doppler shifts in the spectral features. A number of stellar and interstellar lines appear in the spectrum. The following lines showing P-Cygni characteristics have been observed: C III (977, 1175 Å), S IV (1062, 1072 Å), P V (1117 Å), Fe III + Si IV? (1122 Å), P V + Si IV? (1128 Å), N V (1238, 1424 Å), Si IV (1393, 1402 Å), and C IV (1549 Å). The centers of the absorption components of the P-Cygni lines yield radial velocities of from -200 to -800 km/s while the peaks of the emission components are shifted by +400 to +800 km/s. These velocities are significantly larger than the projected orbital velocity of about 200 km/s

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and indicate that gas motions in the system are occurring. A mass-loss rate of about $3x10^{-6}$ solar mass per year is estimated. A few photospheric absorption lines from the 07f component are also present. Analysis of the data shows that the high temperature gas giving rise to the P-Cygni features in the far ultraviolet spectrum is located primarily around the entire binary system and does not share in the motion of either component. The effects of radiation pressure on the Roche (Jacobian) equipotential surfaces and in generating a stellar wind are discussed and the spectral findings are compared with ultraviolet observations of β Lyrae.

Massive Contact Systems (Kam-Ching Leung, U. Nebraska).

In recent years more realistic models employing the Roche model have been developed. As a result of these new approaches many systems which we believed to be in contact have been proven to be either semi-detached or detached systems. At the same time, many true contact systems were found. Those systems identified were almost entirely among low mass stars--W UMa type systems.

We have chosen twelve promising candidates in our initial study of massive contact binaries. All the systems in this study were analyzed with the Wilson and Devinney programs. To start with, we always assumed a system that was detached and let the photometric solution evolve its final least square solution. It was found that nine out of twelve systems selected were contact binaries. In the cases where radial velocity curves or other information are available the absolute dimensions of the systems are calculated. It was discovered that there were two groups of contact binaries: zero-age contact and evolved contact. The contact systems V701 Sco and BH Cen are members of very young clusters. They are found to be zero-age by the evidences of their ages and radii. The formation of these systems must be the consequence of star fission under critical angular momentum: The angular momentum is not large enough to allow the system to become detached, and not small enough to result in a single star. The systems 29 CMa, AO Cas, V729 Cyg, V1010 Cyg, and V1073 Cyg were found to be, and AU Pup and V535 Ara were suspected to be, evolved contact binaries.

The other three systems investigated, BF Aur, μ' Sco, and V Pup, proved to be semi-detached systems only.

The three contact systems reported by others, SV Cen (Wilson and Starr), V382 Cyg and RZ Pys (Devinney) were found to be evolved contacts.

A Search for Variables Amongst Early Type Spectroscopic Binaries and Be Stars (R. W. Hilditch, St. Andrews, and G. Hill, Dominion Aph. Obs.)

A search was carried out for variables amongst bright, early type spectroscopic binaries, Be stars and mass-losing OB supergiants. From the first three years (1971-73) of this continuing survey, a total of 1808 observations of 42 programme stars have been obtained on the DAO photometric system. Eleven new variables have been discovered including, notably, the O-type spectroscopic binaries 14 Cephei and DH Cephei (NGC 7380-2) and the enigmatic objects HD 187399 and HD 190467. These results will appear in the DAO publications.

Close Binaries with H and K Emission (Daniel M. Popper, UCLA).

Properties of the components of detached main-sequence and subgiant close binaries with H and K emission outside of eclipse are compared with those of detached binaries of similar mass without the emission. Distributions in the mass-color, mass-radius, and HR diagrams lead to the hypothesis that the emission binaries represent a later stage of evolution, towards which the non-emission systems are evolving. The instabilities in periods and in the light curves, characteristic of the emission systems, appear to develop as the more massive component reaches the end of core hydrogen burning and obtains a convective envelope. While it is not necessary to invoke mass exchange in some of the detached emission systems, in others a mild amount of mass exchange, perhaps through an enhanced stellar wind, could lead to their present properties. In some cases considerations of the time scale for evolution may require mass loss from the system.

The Structure of VV Cephei System (K. O. Wright, Dominion Aph. Obs.)

Since VV Cephei will go into eclipse in November 1976, the Victoria observations of the red region of the spectrum obtained between 1956 and 1976 have been studied in order to determine the parameters of the system. Radial velocities of the M-type star have been obtained from fifteen well-defined lines in the region 6322 to 6663 A measured on 123 plates. A period of $7430^{d}.5$ was adopted and the data fitted very well a velocity curve with elements $e = 0.345$, $\omega = 59^{o}$, $V_0 = -20.2$ km s^{-1}, $K_1 = 19.4$ km s^{-1}, T = J.D. 2,438,461.0. The date of mid eclipse computed from these data agrees with the 1957 observed value within twenty days. The orbit of the secondary B-type component of the system was derived from measures of the emission Hα line that was assumed to be formed by an envelope surrounding the secondary star. After subtracting the intensity profile of α Orionis (which represents the M-type component of VV Cephei adequately for this purpose) from the observed intensity profile of the VV Cephei spectrum, an emission profile with symmetrical wings and half-width ∿5 Å was obtained; the centre of this line was assumed to represent the velocity of the secondary star. Values of $K_2 = 19.1$ km s^{-1} and $V_0 = -18.5$ km s^{-1} were found to represent these observations when the other elements found for the primary star were adopted. The difference in V_0 may be explained by the necessity to measure M-type lines close to Hα rather than over the extended range used for the definitive orbit. The ratio of the semi-amplitudes, K_1 and K_2 combined with an inclination of 77^{o} adopted by Hutchings and Wright gives masses of 19.7 and 20.0 $M_{\odot}$ for the M and B star respectively.

The additional absorption features of the Hα profile have been measured relative to the emission line; i.e. they are assumed to be produced by matter between the B star and the observer. The principal absorptions can be explained in terms of a mass of gas flowing from the M star, presumably through the Lagrange point and around the B star. The presence of two strong absorptions differing in velocity by 50 km s^{-1} at secondary eclipse makes this model plausible. An additional emission line with velocity ∿-60 km s^{-1} relative to the B-type star appears at most phases after secondary eclipse; it may be produced by interaction between the gas flowing around the secondary star and the stream coming from the primary star.

The chromospheric spectrum, produced by absorption of the outer envelope of the M star as the B star goes behind the primary, was observed in mid 1975, a year and a half before first contact of the eclipse, which indicates a very extended atmosphere for the M star. This spectrum was well developed by August 1976, particularly for low excitation lines of Ca I, Ca II, Fe I, Ti I, Ti II, Mn I, Ni I, etc.

On the Present Eclipse of VV Cephei (R. Faraggiana, Trieste).

High dispersion spectra of VV Cep have been taken at the Haute Provence Observatory since 1967. A region of the spectrum very sensitive to atmospheric eclipses is around the Ca I resonance line λ 4227. Comparing the spectra taken at different epochs, we noticed that sharp cores are becoming visible first for the lines of ions; among them the strong line of Sc II was appearing first. Next the lines due to neutral elements strengthened and in July 1976 strong Fe I and Cr I chromospheric

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lines became visible. Among the emission lines, starting from December 1974, Fe II 4233 is becoming steadily weaker in comparison with λ 4243; this diminution of intensity may be explained if the Fe II lines are formed in the vicinity of the companion.

An Eccentric Close Binary Model for the X Persei System (H. F. Henrichs and E. P. J. van den Heuvel, Amsterdam).

A model for the X-ray source 3U0352+30 connected with the 6th mag O 9.5V pe star X Per is proposed. It is suggested that a $\sim$ 1.5 $M_\odot$ neutron star pulsating with a $13\overset{m}{.}9$ period is moving in $22\overset{h}{.}4$ around a relatively normal O 9.5V star ($M \sim 20\ M_\odot$) in an inclined, slightly eccentric orbit ($a \simeq 11.2\ R_\odot$; $i \lesssim 53^\circ$; $e \simeq 0.1$) giving rise to a $22\overset{h}{.}4$ modulation in the X-ray flux, produced by capture of stellar wind material from the main star, which slightly underfills its critical lobe at periastron. The apsidal motion of the elliptic orbit may explain the 581^d period observed in the wavelength shifts of the higher Balmer absorption lines. A full paper will be published in Astronomy and Astrophysics.

Physically Accurate Models of Eclipsing Binary Stars (D. B. Wood, NASA Goddard Space Flight Center).

In the 1960's and early 1970's, the synthesis approach grew rapidly, with many workers entering the arena with more and more models; such people as Biermann and Thomas, Cochran, Doughty and Mochnacki, Hill and Hutchings, Lucy, Nagy, Rucinski, Whalen and Moss, Wilson and Devinney, Van Landingham, and others.

At this point, let me stress the importance of using a filter-defined photometric system. In fact, all these models are basically monochromatic, so it is important that observations are made in a narrow or intermediate band system such as the Strömgren uvby.

Most of these synthetic models are based on the Roche model, and many are designed specifically to deal with the contact and over-contact binaries. The models are quite demanding of computer resources. The wood model is designed with practical application in mind. Certain compromises in the physics are made, and approximations introduced, to make the model useful on moderately sized computing facilities and budgets. The basic unique feature of this model which permits it to be run at least an order of magnitude faster than other synthesis models is the use of a triaxial ellipsoid star shape. This permits the use of many closed analytical expressions, and permits the integrations over the apparent disks to be done with Gauss-type numerical quadrature.

All of the models designed so far are geometrically symmetric (E.g. ellipsoids or Roche surfaces) and thermally relaxed, so that they are also photometrically symmetric. The only asymmetry which exists is that due to orbital eccentricity. Obviously many observed light curves are not symmetric, as evidenced by the sine terms in the old rectification process. We are now ready for the next stage of complication in our synthetic models--that of magnetic and hydrodynamic forces. The physical models need to be developed to quantitatively account for the observed "perturbations" of the present generation of synthesis models.

We are now in the "Copernical Revolution" in eclipsing binary research where we no longer need to use more and more epicycles (i.e. rectification) to describe the relationship between the stars themselves and what we observe from our distant vantage point.

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Information Resolution in the Context of Close Binary Photometry (E. Budding and H. Al-Naimiy, Manchester).

Photometric observations of certain eclipsing binary stars have been investigated using recently developed frequency domain techniques. The combination of both minima in the analysis results in a distinct methodological improvement over the single-minimum method discussed hitherto. This improvement has two aspects: (1) increased accuracy of the determined elements, (2) agreement of the results of the two-minimum method with the single-minimum method provides a criterion whereby the self-consistency of the underlying model with its representation of the light curve between minima by a cosine series may be assessed. Such self-consistent solutions may be further improved by the inclusion of "photometric perturbations".

Additionally, an investigation of the infrared light curve of Algol (β Per) was also reported upon.

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COMMISSION 44: ASTRONOMICAL OBSERVATIONS FROM OUTSIDE THE TERRESTRIAL ATMOSPHERE (OBSERVATIONS ASTRONOMIQUES AU-DEHORS DE L'ATMOSPHERE TERRESTRE)

Report of Meetings, 25, 27, 28 and 31 August 1976

PRESIDENT: A. D. Code SECRETARY: R. J. Davis

25 August 1976

BUSINESS MEETING

The President opened the meeting by reviewing the report of the Commission and initiated discussion of the role of Commission 44. R. Bonnet presented a prepared report outlining the important contributions that the Commission, as a multidisciplinary forum, can make, particularly in the climate of ever increasing international cooperation in space research. The President reported that Commission 44 was a co-sponsor of the Joint Discussion 2 (X-Ray Binaries and Compact Objects), Joint Discussion 5 (Stellar Atmospheres as Indicator and Factor of Stellar Evolution), and Joint Discussion 7 (Impact of Ultraviolet Observations on Spectral Classification). Business items requiring action on the part of the Commission membership were reviewed and action deferred until the business meeting scheduled for 28 August in order to permit adequate time for discussion and study of items.

SCIENTIFIC SESSION

E. Jenkins organized a session on the hot interstellar gas component in which reviews of the observational data on the soft X-ray background and of the ultraviolet O IV lines were presented followed by discussions of the theoretical interpretations. These presentations were co-sponsored jointly with Commission 34 on Interstellar Matter. A complete account of these sessions is contained in the Commission 34 report.

27 August 1976

SCIENTIFIC SESSION

This meeting on Stellar Mass Loss, Coronae and Winds was organized and chaired by C. de Jager. The invited review papers are as follows:

Observed Mass Loss of Individual Stars

H. Lamers - Survey of observations of mass loss from ultraviolet observations.

J. Hutchings - Survey of ground based observations providing evidence of mass loss.

Y. Kondo - Observations of MgII resonance lines.

UV and X-ray Observations Related to Stellar Chromospheres and Coronae

A. Dupree - Review of UV experiments for late type stars.

C. Jordan - Comparison of Procyon emission measures with the Sun.

R. Mewe - X-rays from stellar coronae.

Theoretical Aspects of Stellar Coronae, Winds and Mass Loss

T. Hearn - Review of theories on formation of stellar coronae and of mass loss.

J. Cassinelli and L. Hartmann - Predictions of Infrared flux from hot coronae of early type stars.

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28 August 1976

BUSINESS MEETING

I. The Commission members approved the list of proposed members of the Organizing Committee for submission to the IAU Executive Committee.

II. Nominations for Commission 44 Vice President were proposed and R. J. Van Duinen was elected by written ballot. His name was therefore submitted to the IAU Executive Committee.

III. Proposals for new members of Commission 44 having been previously solicited were approved and it was agreed to submit that list to the IAU General Secretary.

IV. The working group appointed at the first business meeting to consider the question of dissemination of information on space flight opportunities and space research activities presented their report. It was agreed that a subcommittee be appointed to publish a Commission 44 newsletter. Y. Kondo was appointed Chairman of the subcommittee on Commission 44 newsletter and J. D. Rosendhal, NASA Headquarters, K. Henize, NASA Johnson Space Flight Center and E. Peytremann, ESA, volunteered to serve on the subcommittee. It was hoped that the chairman could recruit additional representatives to broaden the base of input.

Two to three newsletters per year are envisioned. Initially the newsletter would be distributed directly to a reasonably small mailing list that would include all members of Commission 44 and Presidents of all IAU Commissions. It was also suggested that the subcommittee approach a journal such as Nature or Science in regard to publishing concise summaries of the newsletter. It was agreed that the newsletter would perform an extremely useful function not otherwise provided, as follows:

a. It would include only space research opportunities of direct interest to astronomers.

b. It would have a small mailing list not completely duplicated within the large general mailing lists maintained by the various national space agencies.

c. It would summarize advanced planning, pre-launch announcements of opportunity, and post-launch status announcements of opportunity and give names and addresses to be contacted for further information.

d. It would announce pertinent meetings and symposia.

V. The President reported on discussions with Commission 38 (Exchange of Astronomers) on the proposal that IAU funds might be made available to young astronomers wishing to pursue space research when funds for the necessary travel were not available from any agency. The need for such grants has been considered by Commission 38.

VI. The Commission voted to co-sponsor the IAU Symposium on O stars planned for 12-16 September 1977 in Vancouver B.C., Canada.

VII. The President summarized the Commission 44 special discussion on Absolute Spectrophotometric Calibration of Stellar Fluxes in the Vacuum Ultraviolet, held on 27 August 1976. The Commission members requested that a full report of the discussion appear in this report. A paper prepared by R. C. Bohlin, G. J. Strongylis and F. Beeckmans is found as Appendix A of this report.

SCIENTIFIC SESSION

A comprehensive review of NASA flight programs in astronomy was presented by J. D. Rosendhal. The following is a summary of this presentation.

NASA FUTURE FLIGHT PROGRAMS

1. Dr. Rosendhal began his presentation with a summary of the status of approved programs:

a. IUE (International Ultraviolet Explorer)

Descriptive material on this high dispersion UV telescope is readily available from NASA. Space craft integration has been completed with all flight subsystems and components with the exception of the Inertial Reference Assembly which will be delivered in December 1976. Flight scientific instrumentation is complete except for the spectrograph camera system and the flight fine error sensors. Launch is presently scheduled for the 4th quarter of calendar year 1977. The pacing item is delivery of the spectrograph camera system. Rosendhal presented a summary of approved guest investigator programs: NASA: 47 U.S. programs, ESA: 53 programs, SRC: 45 programs. It is estimated that obtaining observations for the proposals accepted by NASA will require the first 9 months of NASA's share of the observing time. An additional Announcement of Opportunities will be issued by NASA at about the time of launch, for observations beyond the initial 9-month period.

b. HEAO (High Energy Astronomical Observatory)

HEAO-A is on schedule for launch in April 1977, spacecraft and experiments have been mated and systems tests are underway. B is on schedule for launch in June 1978; experiment fabrication is now essentially complete for launch. C is planned for 1979. The world's largest facility for calibration of X-ray telescopes is now in operation at Marshall Space Flight Center. Discussions are currently underway regarding the nature and details of Guest Investigator programs for the HEAO missions. Because it is a pointed instrument, HEAO-B may lend itself more readily to use by Guest Investigators than the other missions which are scanning satellites.

c. Solar Maximum Missions

This mission is the sole approved astrophysics new start in the Fy 1977 NASA budget. Wavelength coverage of instruments ranges between gamma rays and visible wavelengths. Emphasis will be on high spatial and temporal resolution and correlated observations. An Announcement of Opportunity for guest investigators will take place during the summer of 1977. Discussions regarding arrangements for coordination of observations with other satellites (especially ISEE-C) and exchange of data between PIs are now underway.

2. Advanced Planning - Explorers

a. IRAS (Infrared Sky Survey): The phase B study was completed in May 1976. This mission is a strong candidate for an Fy 1977 start. It will be a cooperative mission with the Dutch and British.

b. High Energy Astrophysical Transient (X and γ-ray) Explorer: For observing transient X-ray sources and for locating the sources of γ-ray bursts.

c. Soft X-ray and extreme UV explorer (6 - 950 Å Survey). Both the British and Germans have indicated an interest in cooperating in this effort. An additional study of a scout-class scanning EUV sky survey mission has also been initiated.

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d. UV photometric-polarimetric explorer.

e. Cosmic background explorer

Funds are insufficient for implementing all of these missions. At the completion of the mission definition studies it is planned to have an interdisciplinary panel review the results and assign priorities to various missions.

3. Space Telescope (ST)

Current characteristics and performance specifications are:

Aperture: 2.4 meters	limiting $m_V \sim$ 27th mag.
System f/number: f/24	0.1 arcsec angular resolution
Weight: 9318 kg	λ response: 1200 A thru 1 mm

Provision is made for up to 5 scientific instruments and detectors. The five candidate scientific instruments for the first payload are: f/24 field camera (SEC orthicon), Faint Object Spectrograph (photon counting detector), IR photometer (bolometer), Faint Object Camera (instrument and associated photon counting detector may be supplied by ESA), Astrometer (part of fine guidance system). The actual instrument complement will be selected by evaluation of proposals received in response to an AO. Assuming Fy 1978 new start approval, and Announcement of Opportunity for Focal plane instruments is scheduled for 1st quarter, calendar year 1977 and launch in 4th quarter 1983. No new funding was approved for Fy 1977. Studies are being carried on with remaining Fy 1976 and transition period money. Particular emphasis has been placed on detector development. The Fy 1977 Congressional Appropriations Bill provided that, if the President's Fy 1978 budget contains the ST as a new start, NASA will be permitted to issue an early Request for Proposals for the Optical Telescope Assembly (OTA).

4. Space Shuttle and Support System Module (SSM) and Spacelab.

Orbital flight tests of the shuttle will begin in 1979. The first flight of the spacelab manned module provided by ESA (Spacelab 1) will take place in the 3rd quarter of 1980 and the first flight of the pallet-only version of spacelab (Spacelab 2) is currently planned for the 4th quarter. There will be some very limited opportunities for scientific experiments on the Orbital Flight Tests. Egnineering verification of the Spacelab is the primary objective of Spacelabs 1 & 2 but it is anticipated that there will be opportunities for a substantial scientific program as well. Emphasis will be on atmospheric physics on Spacelab 1 and astrophysics on Spacelab 2. Responsibility for Spacelab 3 (1st quarter of 1981) has been assigned to the office of appplications. Proposals for Spacelab 1 have been received and evaluated and a preliminary payload is now being selected. AO's for the Orbital Flight Tests and for Spacelab 2 will be issued in September 1976. According to current plans there will be a total of 18 flights of the shuttle by mid-1982 and 50 by the end of 1987.

Funds for Spacelabs 1, 2 and 3 are included in the approved Fy 1977 budget. An augmentation has been requested in the Fy 1978 as a first step in building towards a possible level-off-effort program. It is anticipated that discipline oriented AO's will be issued within the next year followed by yearly announcements of new opportunities. Early emphasis will be on interdisciplinary payloads and on smaller PI class instruments. According to current plans emphasis will eventually shift to discipline dedicated flights and the use of larger facility class instruments. Relative balance between PI and facility instruments will depend upon the discipline involved. Facility instruments which have been studied include a meter-class general purpose UV telescope, a cryogenically cooled infrared telescope, a meter-class UV/optical solar telescope, a hard X-ray imaging solar telescope, and solar EUV, XUV and soft X-ray telescopes.

The session on scientific results from recent spacecraft was chaired by R. Bonnet. The presentations were as follows:

P. Wesselius - Ultraviolet Photometry Experiment, Astronomical Netherlands Satellite.
M. Marov - Venus probes, Venera 9 and 10.
P. Cruvellier - Ultraviolet observations from D2B Aura Satellite
J. P. Delaboudiniere - Solar Spectroheliograms from D2B.
G. Brueckner - High spectral and spatial resolution solar rocket measurements.

31 August 1976

SCIENTIFIC SESSIONS

Reports on solar observations from Sky Lab and from OSO-8 were presented in an all day session held jointly with Commission 10 (Solar Activity) and Commission 12 (Radiation and Structure of the Solar Atmosphere). The Sky Lab presentations were organized by R. MacQueen and the OSO-8 presentations by R. Bonnet. Details of the program are to be found in the report of Commission 10.

Appendix A

A COMPARISON OF ABSOLUTE FLUX MEASUREMENTS OF STARS IN THE ULTRAVIOLET

R. C. BOHLIN*, G. J. STRONGYLIS*, AND F. BEECKMANS†
*GODDARD SPACE FLIGHT CENTER †INSTITUTE d'ASTROPHYSIQUE

Measurements of the absolute spectral-energy distribution of stars have a long history, with most ground based efforts concentrated on the star Vega (see review by Oke and Schild 1970 and Hayes and Latham 1975). The accuracy of the Vega calibration is about 5 percent from 3300 to 10800 Å. In the rocket ultraviolet, the precision is worse, but the maximum difference between several modern measurements is now only 35 percent. The problem of defining a network of known standard stars is best broken into two parts. First, what are the relative fluxes between a single standard star and a larger set of stellar spectra, as measured by a photometric spectrometer? Second, what is the absolute flux of a single standard star? The ultraviolet standard chosen is η UMa B3V, because it is the best measured star with substantial flux near and shortward of Lα.

To investigate the question of what sets of available data are from photometric instruments, individual scans are compared in Fig. 1 with scans of the same star obtained by OAO-2 (Code and Meade 1976). To compute the flux ratios shown, the data of higher resolution were averaged over the bandpass of the lower resolution instrument. The values labeled Bohlin are revisions downward by about 10 percent of the Bohlin, et al. (1974) calibration. The revisions (Bohlin and Strongylis 1976) are necessary, because better O_2 cross sections and air extinction coefficients were discovered in the literature. The extinction of air over a 73m path in the laboratory was needed to obtain the absolute calibration of the flight detector from a standard NBS tungsten lamp. The three stars from TD1-S2/68 appear in Humphries, et al. (1976) and the ANS data is from Wu (1975). The independent measurement of the flux from γ Ori by Hessberg, et al. (1975) are in disagreement with the data discussed here with ratios to OAO-2 from 0.05 at 1250 Å to 1.43 at 2200 Å. A similar problem exists with the fluxes of Evans (1972).

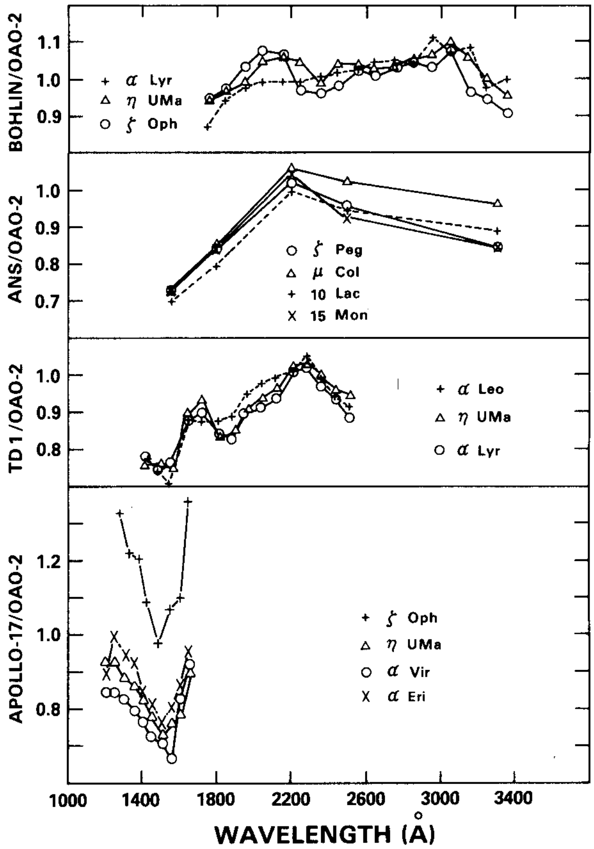

Fig. 1. The ratios of absolute fluxes of four independent measurements to the final fluxes derived from the OAO-2 satellite.

The deviation of the points in Fig. 1 from unity represents the difference between the absolute fluxes of OAO-2 and the other data. The typical spread in the ratios of ±3 percent for each experiment is a measure of the reproducibility of the data relative to OAO-2. The Apollo 17 spectrum of ζ Oph (Henry, et al. 1975) has an uncertain background correction and should not be considered (Henry, private communication). The ratios for the other three Apollo 17 stars shown and a fourth star α Gru have a mean scatter of about ±5 percent. Averages of the mean TD1/OAO-2 ratios for 25 stars are given in Table 1 and have a 1σ mean error of ±1 percent. Consistent ratios from star to star do not prove that an instrument is photometric, but any errors, therefore, must be common to all five experiments.

Assuming that all five sets of data are actually photometric and that Fig. 1 and Table 1 represent the differences between their calibrations, the determination of the absolute flux from one star will permit corrections of all five sets of photometry to a common absolute scale. Various measurements of the flux of the primary standard η UMa are shown in Fig. 2. The results of Stecher (1968) assume that the response of sodium salicylate is flat and are shown as averaged values over 100 Å bandpasses. Code and Meade (1976) have normalized the long wavelength OAO-2 data to the ground based fluxes of the Hayes and Latham (1975) scale. The maximum difference among the data shown in Fig. 2 is 35 percent near 1500 Å. Longward of 1700 Å, most values agree to about ±5 percent.

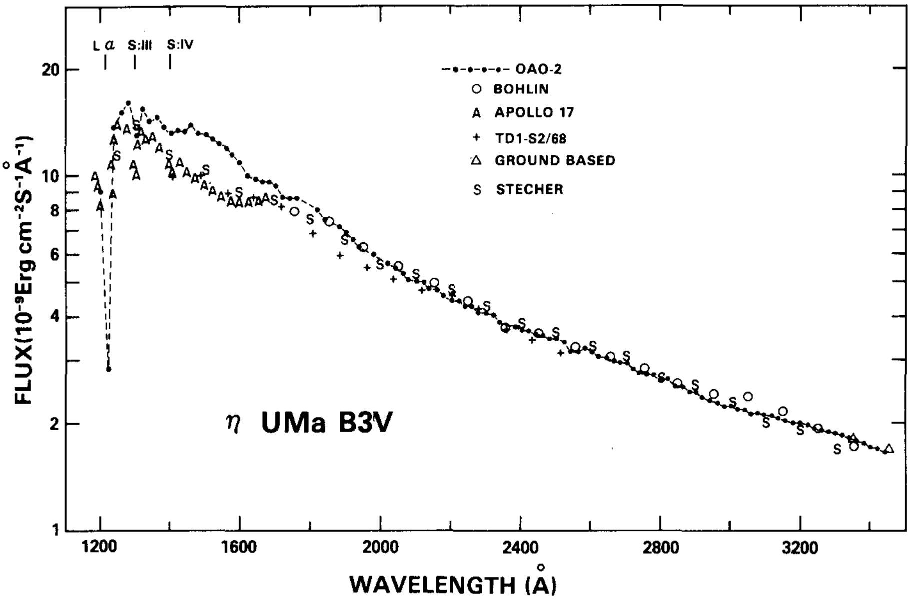

Fig. 2. The absolute flux of η UMa from various experiments.

More measurements of absolute flux values are needed, particularly in the 912 to 1700 Å range. For the present, the best estimate of the UV flux of η UMa might be obtained by using a model stellar atmosphere as an interpolating device to fit the points shown in Fig. 2 (Bohlin and Strongylis 1977). For effective temperatures near 1700°K, neither line-blanketing nor non-LTE effects in the models are a serious problem.

Table 1

Mean Ratio of TD1/OAO-2 for 25 Stars

λ (Å)	Ratio	λ(Å)	Ratio
1400	.789	2050	.978
1450	.797	2100	.984
1500	.753	2150	1.005
1550	.734	2200	1.011
1600	.794	2250	1.015
1650	.907	2300	1.008
1700	.920	2350	.975
1800	.859	2400	.965
1850	.868	2450	.951
1900	.871	2500	.934
1950	.906	2540	.949
2000	.948		

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COMMISSION 45: SPECTRAL CLASSIFICATION AND MULTIBAND COLOUR INDICES (CLASSIFICATIONS SPECTRALES ET INDICES DE COULEUR A PLUSIEURS BANDES)

Report of Meetings, 26, 27, 28 and 31 August 1976

PRESIDENT: C. Jaschek. SECRETARY: N Houk.

26 August 1976

I. SCIENTIFIC MEETING

P.C. Keenan (U.S.A.) discussed his revised spectral classification for the cooler stars, based on the original MK system with the addition of abundance indices for stars which differ from the sun in composition. The system is defined and illustrated in a forthcoming photographic atlas.

G. Cayrel, R. Foy and F. Spite (France) all briefly spoke on the spectral classification of metal deficient stars. There seems to be a tendency to classify such stars too early and to underestimate their luminosity. Also, because of lack of standards, the classifications vary between observatories; it is suggested that giving a general indication of the abnormality is sufficient.

Garrison (Canada) reported that an MK - UBV study (with W.A. Hiltner) of OB stars south of $\delta = -20°$ and brighter than B = 10 has been completed and is in preparation for publication. A second program of classifying very homogeneously all stars in both hemispheres brighter than $V = 4^m75$ is under way, using the new forthcoming Atlas of Morgan and Keenan.

E.E. Mendoza V (Mexico) reported that Hα and OI (λ7774Å) photometry of over 100 main-sequence A stars shows that this photometric system neatly separates the metallic-line (Am) stars from normal A stars.

J.R. Mould (United Kingdom) discussed abundance effects on the classification of four M dwarfs. The strength of the γ(0,0) band of TiO at a given temperature is a coarse abundance indication. The CaH bands provide a clear-cut separation of giants and dwarfs but abundance also has an effect.

A.M. Hubert-Delplace (France) reported that she and H. Hubert will publish a photographic spectral atlas of 40 northern hemisphere Be stars (77Å/mm) showing typical spectral variations. The stars were selected from about 200 emission-line stars observed in a program by Mrs. Herman et al. since 1955.

Wing (U.S.A.) reported the identification of the feature observed near 9900Å in M dwarfs and S stars as FeH, as suggested by L. Nordh, although stellar observations of higher resolution are needed for confirmation.

Th. Schmidt-Kaler (Federal Republic of Germany) discussed a pilot project on classification of stars of type F2 and earlier from Hamburg Schmidt objective-prism plates (600Å/mm on Hα). The measurements, reductions, and classification procedure are all carried out on a mini-computer, with 2000-3000 stars per plate being analyzed. Under best conditions it is possible to get two-dimensional types with an accuracy approaching that of MK classification.

H. Richer (Canada) reported on work with Olander and Westerlund on carbon stars in the Large Magellanic Cloud identified by Westerlund. So far VRI photometry for 103 objects and slit spectra of 20 have been obtained, in the range $11^m9 < I < 13^m7$. The spectra indicate a large range in the abundances of C^{13} in these stars.

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Golay (Switzerland) pointed out that because of its accuracy, homogeneity and the large number of stars measured, the Geneva ($UBVB_1B_2V_1G$) system is well suited for sorting stars of similar colors into photometric "boxes." Stars in the same box are nearly the same also in spectral type, Hβ index, Copenhagen photometry, UV and IR photometry, and absolute magnitude. Since the range of absolute magnitudes of stars in the same "box" is within .1 mag, a calibration can be made to obtain distance moduli of stars and clusters from such Geneva photometry.

Bidelman (U.S.A.) reported that an extension list of shell stars will appear as an appendix to IAU Symposium No. 70 on Be and Shell Stars. Also in the lists are some of the more notable P Cyg stars, a few eclipsing binaries and some early-type stars involved in nebulosity. Bidelman also noted that he plans to make available in the near future numerous hitherto unpublished spectral classifications by the late G.P. Kuiper of faint high-proper-motion stars.

27 August 1976

II. ADMINISTRATIVE MEETING

Activity Report

The President reported about the Commission activities since the last Assembly. The main points are the following:

a - Meetings organized: IAU Symp. No. 72 on "Abundance Effects in Classification" held on July 8-11, 1975, at Lausanne. The meeting was dedicated to Dr. W.W. Morgan; the proceedings are being published by P. Keenan and B. Hauck at Reidel.

b - Meetings co-sponsored: IAU Colloquium No. 32, "Physics of Ap Stars," at Vienna on 8-10 September 1975; the meeting on "Multicolor Photometry and the Theoretical HR Diagram" organized by D. Philip, at Albany on October 25-27, 1974; IAU Colloquium No. 35 on "The Compilation, Critical Evaluation and Distribution of Stellar Data " at Strasbourg on August 19-21, 1976. The Commission has also co-sponsored the Joint Discussions on "The Impact of Ultraviolet Observations on Spectral Classification" and on "The Galactic Structure in the Direction of the Polar Cap" held during the present Assembly.

c - Circulars: Four circulars were mailed to all Commission Members and about ten to the Organizing Committee Members.

d - The Commission report was divided in parts, each one written by a different specialist. Due to an unfortunate shortening of Dr. Bidelman's report, it became almost useless and circulation of an unabridged version is recommended. In the ensuing discussion the usefulness of the Commission report was questioned. It was finally suggested that an effort should be made next time to circulate the report before the Assembly and that members should be provided with a more detailed report than the one that is printed by the IAU.

e - Grant: Upon the recommendation of the Commission, the IAU made a grant of $1000 (U.S.) to Dr. P. Keenan for the publication of his "Atlas of Spectra of Stars of Types Later than GO."

f - The President of the Working Group reported on its activities. (See Commission report).

Questions Submitted to Vote

The members accepted by vote:

a - to co-sponsor the meeting on the "HR diagram" on the hundredth anniversary of H.N. Russell, as proposed by Philip for October 1977. The Commission representative will be van den Bergh.

b - to co-sponsor the meeting on the "Photometry of Emission-Line Objects" as proposed by Grygar, to be held at Hvar in October 1977. The Commission representative will be Cester.

c - the following two rules for the Organization of the Working Group: 1 - The com-

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position of the WG is to be examined at each Assembly. 2 - The chairman of the WG is proposed by the group and is appointed by the Commission for three years.

d - the proposed new organizing Committee (confirmation of previous mail ballot): B. Hauck (Switzerland), President; A. Slettebak (USA), Vice-President; Ardeberg (Sweden); Bartaya (USSR); Cowley (USA); Jaschek (France); Keenan (USA); Kharadze (USSR); Mendoza (Mexico); Straizys (USSR).

e - the proposal of the new IAU members (confirmation of previous mail ballot): Albers H. (USA) and Claria J. (Venezuela).

f - the new Commission members: Albers H. (USA), Bell R.A. (USA), Crampton D. (Canada), Hill P.W. (UK), Lutz J. (USA), Maeder A. (Switzerland), Maehara (Japan), Morguleff N. (France), Osborn W. (Venezuela), Pasinetti L.E. (Italy), Wesselius P.R. (Netherlands).

g - the new consultant members: Levato H. (Argentina), Mead M. (USA).

h - the composition of the Working Group on Spectroscopic and Photometric Data: Jaschek C. (Chairman), Barbier M., Bidelman W.P., Dluzneyskaya O., Hauck B., Houk N., McCarthy M., Mead J., Nandy K., Philip D.

28 August 1976

III. JOINT MEETING OF COMMISSIONS 29, 36 AND 45 ON "CLASSIFICATION CRITERIA FOR NON-NORMAL STARS"

A.P. Cowley (U.S.A.) and H. Houk (U.S.A.) summarized the way non-normal stars are classified in the Michigan Spectral Catalogue. The technique involves using features in normal MK standards of more than one spectral type to give a rough indication of the degree as well as the type of the peculiarity. For example, a K2 III with strong CN similar to that found in a supergiant might be designated K2 III CN Ib. The method has the advantage of not requiring use of numerous non-normal standards, but for some types of peculiarity and for some strong cases, a verbal remark is required to adequately describe the spectrum. Volume 2 of the Michigan Spectral Catalogue, containing over 30 000 HD stars from $\delta = -53.0°$ to $-40.0°$, will probably be available around September 1977, but no orders should be placed until an announcement of availability is made.

Pagel (United Kingdom) spoke on two subjects. Regarding the classification of extreme metal-weak stars, he noted that work by Spite shows that the necessary information is present in 80Å/mm spectra, but not easy to extract. In visual classification, the absolute strength of the Balmer lines is a good temperature indicator only for Teff > 5200. Comparison of metal lines then gives a useful indication of line weakening. Luminosity is indicated by λ4173, but only well enough to distinguish two classes. Within these limits the classification by Bond gives very reasonable results and led him to discover subgiant CH stars.

Secondly Pagel discussed the Wilson Bappu effect. He has developed a simple scaling law which supports the hypothesis of optically thick Doppler broadening for the full width at half maximum of Ca^+K2 and Mg^+K2 and provides a theoretical basis for metallicity affecting Mv(K). Whether this effect exists seems to depend on which calibration is adopted for Mv(K), an unsettled question; one must be able to allow for errors in the reduction to absolute parallax.

Mrs. Herman (France) reported on progress in the classification of Be stars.

31 August 1976

IV. JOINT MEETING OF COMMISSIONS 25 AND 45

A.G.D. Philip (U.S.A.) summarized his analysis of the Hauck-Mermilliod Catalogue of homogeneous four-color data. Estimates of the values of the astrophysical parameters Mv, θe, log g, and $[Fe/H]$ as well as for the color excess E b-y were made for 5183 stars of spectral type O through F. The probable errors for the calculated values for Mv, θe, log g, and $[Fe/H]$ were ±0.4, ±0.01, ±0.13 and ±0.1 respectively.

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H.U. Nørgaard-Nielsen (Denmark) spoke about the application of trigonometric parallaxes for absolute luminosity calibration of photometric systems. He demonstrated that it is very difficult to avoid introducing systematic errors into absolute magnitude calibrations caused by accidental errors in the trigonometric parallaxes. Nørgaard-Nielsen thinks that the widely used corrections by Lutz and Kelker contain fundamental errors.

A. Maeder (Switzerland) discussed problems of photometry and stellar structure in relation to basic calibrations. The relation between a) the deficiency of stars near A7-F0 (MS gap), b) the location of the cool edge of Am and δ Scuti stars, and c) the difference in photometric effects of rotation and the appearance of efficient convection in outer stellar layers is emphasized. The effect on the basic Teff calibration, and the influence of the overshooting from convective cores on age and mass calibrations were also pointed out. A similar discontinuity is located at B6-B7.

G. Cayrel (France) gave a report (co-authors Foy, Hardorp and Perrin) on a determination of the metal content of the Hyades. A careful comparison made between the results obtained using different photometric systems ($[Fe/_H] = + 0.25 \pm 0.08$) and those by detailed analysis ($[Fe/_H] = + 0.08 \pm 0.15$) shows that a small discrepancy still exists. As a byproduct HD 76151, proposed by Hardorp as a solar-type standard, was analyzed in detail. Results: Tef = 5600, log g = 4.44; $[Fe/_H] = - 0.06 \pm 0.15$.

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COMMISSION 46: TEACHING OF ASTRONOMY (ENSEIGNEMENT DE L'ASTRONOMIE)

Report of Meetings held in Grenoble

PRESIDENT: D. McNally. SECRETARIES: J. M. Pasachoff, D. Wentzel.

Session I, 25 August 1976

I. REPORT OF COMMISSION

The President's report of the activities of Commission 46 for the period 1973 - Jan. 1976 was approved.

II. NATIONAL REPORTS

The form of the National reports was approved. In a discussion of the form of the report, it was suggested that reports should be brief and take account of the reports previously published. New developments should however be treated in extenso. The report should cover university, school and public education in astronomy and related subjects.

III. MEMBERSHIP

A. Organising Committee

By virtue of the constitution of Commission 46 E. A. Müller and T. Swihart leave the organising committee, H. E. Jørgensen also retired. They are replaced by W. Buscombe, L. Mavridis, B. F. Peery and A. Riguelet-Kaswalder. The organising committee for the period 1976-1979 is given at the head of this report.

B. Members of the Commission

During the period 1973-76, N. P. Grushinsky (USSR), J. Riihimaa, (Finland) resigned, S. Torres-Peimbert resigned as national representative of Mexico, but remained a member of the Commission. W. Buscombe (U.S.A.) and S. E. Okoye (Nigeria) joined the Commission. The following new members were proposed and approved:

Canada:	J. E. Kennedy,
France:	M. Gerbaldi, L. Bottinelli,
GDR:	H. Zimmermann,
Spain:	Catala-Poch, Mª. A.,
U.K:	V. Barocas, D. Clarke, D. R. Fawell, H. G. Miles,
U.S.A:	J. M. Pasachoff, B. F. Peery, R. R. Robbins,
U.S.S.R:	V. V. Porfir'ev,
Yugoslavia:	B. M. Ševarlić.

C. Consulting Members

The list of consulting members of the Commission was reviewed. The list of consulting members is considered to lapse at each General Assembly and a list drawn afresh. All retiring consulting members are eligible for reappointment. The list proposed and adopted for the period 1976-1979 is given at the head of this report.

In a discussion on membership the following points emerged.

(i) Each country adhering to the Union had the right to nominate a National Representative to Commission 46. Care should be taken to ensure that National

Representatives had an intimate connection with astronomical education and a direct connection with some aspect of such education. National Representatives had the responsibility of maintaining contact between Commission 46 and its projects and national astronomical education.

(ii) In order to maintain the vitality and range of interest of Commission 46 additional membership was necessary. Additional members should be selected with reference to the special expertise they can offer the Commission.

(iii) With membership now at 68 undue proliferation of members should be avoided - in particular a policy of deletion and retirement of inactive members should be actively followed.

IV. RELATIONS WITH ICSU, UNESCO, COSTED AND OTHER BODIES

The President reported on relations between Commission 46 and ICSU, UNESCO, and COSTED. The content of his remarks may be found in the report of Commission 46, IAU Transactions XVI.

The President was kept informed of the work of other bodies such as Task Group for Education in Astronomy (TGEA) in the United States, the Royal Astronomical Society's Education Committee in the U.K., the activities of the International Society of Planetarium Educators among others. One notes the work done by these bodies e.g. the introduction of astronomy in the National Parks by TGEA, the preparation of teaching units by the RAS and the exchange of ideas for keeping the public informed of planetarium visits by ISPE. There is one resource which needs stressing and that is the local astronomical society. These are a valuable resource in that young people could first get to know a little about astronomy in the company of enthusiastic amateurs - this is a large resource in many countries and one which we should capitalise more heavily.

<u>Session II, 27 August 1976</u>

V. VISITING PROFESSORS' PROJECT

In a written report M. Rigutti recommended the termination of the Visiting Professors' Project in the absence of tangible financial support. Whilst sympathising with Rigutti's analysis, the Commission decided to keep the project alive to the extent that the purpose of the project should be advertised in the Information Bulletin, that persons interested in giving lectures, meeting with astronomers etc., in developing countries should send their names to Rigutti who would inform the appropriate National Representative who could then take action to make the necessary arrangements. This form of the project should be reviewed in 1979.

VI. EXCHANGE OF EQUIPMENT WORKING GROUP (JOINTLY WITH COMMISSION 9)

L. Houziaux reported that it had proved very difficult to find institutions with equipment to donate or lend to this project and impossible to find acceptable arrangements to provide for transport and installation. With the agreement of the Presidents of Commission 9 and 46 it was agreed to terminate this project.

VII. BOOK PROJECT

L. Houziaux reported a situation similar to that for Exchange of Equipment existed. While suggesting joint consultation with Commission 5, he felt there was no extensive pressure for its continuation. It was clear from the ensuing discussion that many members of the commission felt that there was still a need for the Book project. The following suggestions were made.

(a) That the IAU should endeavour to donate some copies of its publications to developing countries even though this involved the IAU in some expense.

(b) That publishers generally might make available some copies of books free or at a low charge, though the copyright difficulties and financial stringencies were recognised. But it was pointed out that even a few copies would help.

(c) That Commission 46 might prepare a select list of textbooks with a view to indicating those texts most advantageous for instructional purposes.

(d) That duplicate journals might be sent to a corresponding institution in a developing country.

Professor Houziaux undertook to look into these matters with a view to seeing what could be acheived in practical terms.

VIII. INTERNATIONAL SCHOOLS FOR YOUNG ASTRONOMERS (ISYA)

The details of all ISYA held in the period 1973/76 have been given in the report of the Commission in IAU Transactions XVI. There was an extensive debate on the nature, character and future of the schools. The following salient features emerged.

(a) The geographical range of the schools was considerable: Asia, 2 (India, Indonesia); Europe, 3 (Greece, Italy, U.K); South America, 2 (Argentine).

(b) Although the schools were originally held under joint IAU/UNESCO auspices, the Commission accepted a suggestion by the Executive Committee that UNESCO should now be dropped from the title of the schools in view of the fact that UNESCO now make no direct financial contribution in support of the schools. It was recognised that some advantage did exist through association with UNESCO and that some indirect financial support was obtained.

(c) It was concluded that sites for schools should be chosen with due regard to effectiveness of instruction in astronomy and support for existing astronomical communities.

(d) The Executive Committee had insisted that, before IAU finance could be made available for future schools, better rules than presently existed, for the operation of the schools, would be needed. Draft proposals were rejected by the Commission on the grounds that the freedom of action of the Secretary of the ISYA would be fettered unnecessarily. A committee (President, Houziaux, Wentzel) was constituted to draft more acceptable rules and guidelines. The new rules and guide lines were presented at a later meeting and accepted. The Rules and Guidelines for the operation of the ISYA are appended to this report.

(e) Commission 46 wishes to record:

(i) that it regards the ISYA as the project of the Commission which has highest priority.

(ii) its warm appreciation and approval for the work of Kleczek in organising the ISYA.

Session III, 30 August 1976

IX. ASTRONOMICAL EDUCATIONAL MATERIAL (AEM)

The next update of AEM for 1979 will be prepared by:

B. F. Peery assisted by R. R. Robbins : English Language Material.

E. V. Kononovich assisted by C. Iwaniszewska *et al* : Slavic Language Material.

L. Mavridis assisted by A. E. Jørgensen : Material in all other languages.

It was agreed that the collators of AEM should have the assistance of a further person in addition to the help expected from National Representatives in the form of information on new material.

In a discussion of AEM the following points emerged:

(a) The cost of producing and distribution of an update of AEM for a single language group is of the order of $300. This cost is borne by the collator's institution, the IAU having no funds for this purpose.

(b) While it would be desireable from many points of view to give clear recommendations in favour of a selected list of material, it was not only invidious but impractical for the collators to undertake further selection of material recommended. However, it was agreed to classify material more carefully in relation to its use in teaching (noting that many reviews of textbooks made little reference to pedagogic value) particularly in regard to level and degree of sophistication.

(c) Evaluation of text books at upper school/university level in major international and semi international languages should have high priority in (b).
(d) The Commission should seek recommendations for translations and encourage publishers to produce the texts so translated.

X. PROJECT CONTRATYPE

M. Gerbaldi reported that the trial period for ordering material (56 2 × 2 slides) of the Project held at the Institut d'Astrophysique in Paris had resulted in 32 orders - 18 of these orders were from European Astronomers 8 from Universities and 6 from teachers. The first six slides of the material of the Project held in Moscow were received by the Commission but with no assessment of demand.

It was clear that the aim of the Project to get good teaching materials into the hands of teachers, particularly in the developing countries had failed. The following steps to remedy this situation were proposed.

(a) Dr. West of ESO and Dr. Littmann Director of the Hansen Planetarium (a non-profit making educational enterprise) have expressed interest in marketing the Project Material. It was agreed to explore with Dr. West and Dr. Littmann how the Project Material might be marketed.

(b) It was further agreed that certain other bodies e.g., the Royal Astronomical Society, might be approached to see if they might act as further outlets for the material.

(c) The need for documentation of the material was also pressed. This question will be actively addressed by Gerbaldi and Wentzel. Gerbaldi already has documentation for a set of slides on gravitation.

(d) It was noted that profound difficulties existed in making known the existence of this material in the developing countries. Once the future of the Project was settled National Representatives would be required to take steps to locally advertise the existence of the project.

E. E. Proverbio briefly reported on a scheme with integrated illustrative material now being used in Italian Schools. The material was expressly designed for young children.

XI. A NEWSLETTER FOR COMMISSION 46?

The President pointed out that he receives a great deal of correspondence from members of the Commission. In that correspondence there is a great deal of material of interest to the entire Commission. Because it would be burdensome to circulate all such correspondence to all members of the Commission it is a pity that such items may be referred to only briefly in a report. There is a need to broaden the exchange of ideas between Commission Members rather than use a presidential filter. The Education Committees of other Scientific Unions had found it useful to establish a newsletter. These ranged in style from a 4000 circulation, 16-page quarterly of IUPAC to the four-page newsletter of IUB.

The President proposed that the Commission might experiment with an 8-page Newsletter published twice a year. The President volunteered to serve as editor to get the Newsletter established. This suggestion was accepted by the Commission. D. Wentzel offered to produce and distribute the Newsletter from Maryland. Some funding might be available from the IAU to help defray the costs of production and distribution. It is hoped to present the first issue of the Newsletter in January 1977.

XII. FUTURE MEETINGS OF THE COMMISSION

It was agreed that a whole day should be given to a discussion of Teaching Methods for Astronomy at University Level. Professors Climenhaga and Ovenden were asked to consider the organisation and format of such a meeting during the Montreal General Assembly. Such a meeting would be additional to the meeting of the Commission with Canadian Schoolteachers.

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Session IV, 30 August 1976

THE TEACHING OF ASTRONOMY

This session divided naturally into two parts - the first on the teaching of astronomy specialists and the second on the teaching of astronomy to non-specialists.

McNally referred to the importance of specialist courses for astronomers in view of the way astronomy was developing. Astronomy is both a pure and an applied science in its own right and not a branch of some other discipline. However, in its role as applied science, astronomy must indent heavily on other sciences and it was essential to ensure that desireable developments in the teaching of these sciences did not prove detrimental to instruction required for Astronomy. A clear example is the trend towards pure, and away from, applied mathematics but there were areas of physics where a growing neglect in the curriculum could be detrimental to astronomy teaching. Rigutti stressed the need to make astronomy available to students before postgraduate level in order that they should appreciate the role played by astronomy in our cultural heritage. Iwaniszewska outlined the astronomy programme in Polish Universities for astronomy specialists and teachers of astronomy. Okoye urged that an international centre be established to support training and continuing study for under-developed countries. He also raised a number of thought provoking issues regarding the role of astronomy in relation to education in the developing countries. Kourganoff stressed that astronomy was an integrating science and astronomers should be trained with this in mind and not as an adjunct of physics - it was not recognised by practitioners of other sciences that the problems of astronomy required astronomical solutions. He favoured an early acquaintanceship with astronomy and certainly no later than the early years at university. A lively discussion ensued clearly indicating the need for a more extended meeting on these topics.

Haupt (Austria) reported on a survey of 18 year olds aimed at assessing how much astronomy had been retained from their courses at school. The results were very encouraging e.g. 45% of the sample could correctly discriminate between astronomy and astrology. Robbins described an astronomy programme devised at the University of Texas for teacher training through active participation in experiments designed for classroom use. Friedmann reported on the methods being used in the GDR to train teachers for the astronomy section of the new school science curriculum. The courses take two years and are backed by summer schools designed to promote confidence in presenting astronomy. Sandqvist reported on the apprenticeship scheme operating in Sweden where astronomy is offered as an option for 9th grade students. This scheme is designed to give career guidance. Participation in the scheme, while demanding on the institution, had been found to be rewarding.

Extra Session

The tele-recording of the Royal Astronomical Society's first Young Person's Lecture" - "Not Seeing is Believing" by D. Sciama was shown. This tele-recording of 50 minutes duration is available in colour from Dr. A. Crilly, Open University, Alexandra Palace, Wood Green, London N.

2 September 1976

MEETING WITH FRENCH SCHOOL TEACHERS

About 150 teachers and 50 astronomers attended.

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Information was given on:
1) the new programmes for physics teaching in French schools,
2) the pedagogical and audiovisual material available,
3) the teaching of astronomy at the same level in different countries: Belgium, Canada (Quebec), Poland and Switzerland.

Discussions were held on:
1) The training and permanent recycling of teachers for astronomy.
2) Astronomy Clubs.
3) The teaching of Astronomy during "free" activity sessions.
4) The importance of Astronomy at secondary level:
   a) in the first cycle (11-14 years) it helps the children to understand their surroundings.
   b) in the second cycle (14-18 years) the universe can be taken as a good laboratory.

Resolutions were adopted concerning:

The introduction of astronomy in physics programmes.
The permanent recycling of teachers.
The organisation of a Summer School in 1977.
The development of audio-visual material.

An exciting keynote address was given by Dr. Bonnet on "Astronomy in the era of investigation from space".

Particular thanks are due to Professor Omnes, president of the "Commission Laganique" and Professor Schatzman vice-president of the French Physical Society who both co-sponsored the meeting, Professors Gie and Lena who chaired the sessions, the "Inspecteurs Generaux" Delarue and Guinier who attended the meeting, Mme. Coq, Drs. de la Cotardiére and Delacote who chaired the working groups, and Professors Houziaux, Iwaniszewska, Landry, Lena, de Loore, Maeder and Terlon who made important contributions. The meeting received financial support from the French National Committee of Astronomy and from the Ministry of Education. Their support is gratefully acknowledged as is the unstinting help and support of Lucelle Bottinelli and Michele Gerbaldi with the organisation of the Meeting.

L. Gougenheim - Local Organiser.

RULES AND GUIDELINES FOR INTERNATIONAL SCHOOLS FOR YOUNG ASTRONOMERS

A. RULES:

1) The President, Vice-President(s), Secretary of the ISYA and Past President will constitute a sub-committee of Commission 46 to regulate the organisation of the ISYA. The Secretary of the ISYA will be the Secretary to the sub-committee and will keep the sub-committee informed of all proposed ISYA, the details of their organisation and evaluation. The President of the Commission will inform the General Secretary of the Union of the programme for each proposed School only when approved by the sub-committee.

2) The Secretary of the ISYA at each General Assembly will ask the opinion of the Commission for possible venues, topics, lecturers for ISYA in the succeeding 3 year period.

3) The ISYA sub-committee will meet at least once during each General Assembly following discussion in the full Commission to discuss the suggestions, order of priorities and discuss the evaluation of previous schools. A report on immediate past schools and plans for future schools should be submitted to the IAU Executive Committee by the President.

B. GUIDELINES:

1) The choice of venue, topic(s), lecturers and general calibre of students for each ISYA should be carefully considered with respect to local conditions and

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goals, e.g. a school may be held to support astronomy at an embryonic stage, or to support a growing astronomical activity, or to explain and demonstrate techniques.

The goals of each school should be carefully stated in advance. Topics should be directly appropriate to local conditions and lecturers should be chosen with due regard to the contribution they may be expected to make towards the realisation of the goals of the school.

2) The students should have an adequate academic background to profit from the school (normally a person with a degree in physical or related sciences from an established university or institution of similar standing or, a person undergoing training in an established observatory). Students of inadequate academic background are unlikely to profit, and should be discouraged from attending the schools, as they may hinder the progress of the majority of the better qualified students.

As far as practicable, the local organiser of the school must inform the Secretary of the ISYA and the ISYA sub-committee of the qualifications of the proposed students. The sub-committee may at its discretion ask for the removal of any proposed student who is believed to be inadequately qualified.

3) The Secretary of the ISYA, one year after each school, should collect such information as is necessary to evaluate the school.

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COMMISSION 47: COSMOLOGY (COSMOLOGIE)

Report of Meetings 25, 26, 28, 30 and 31 August 1976

PRESIDENT: M.S. Longair.

25 August 1976

BUSINESS MEETING

The President described Commission activities since the last General Assembly. The Commission had cosponsored IAU Symposium No.74 "Radio Astronomy and Cosmology" jointly with Commission No 40 (Radio Astronomy). Over 150 invited participants from outside Cambridge attended the Symposium for which the hosts were the members of the Radio Astronomy Group, Cavendish Laboratory, Cambridge.The emphasis of the symposium was upon those aspects in which studies of discrete radio sources can provide cosmological information. All observational evidence available at the time of the symposium was surveyed in depth by the astronomers who had made the observations. The proceedings which will be published shortly by D. Reidel and Co. and for which the editor is D.L. Jauncey will provide a complete survey of how radio astronomical observations can contribute to cosmological problems.

Certain members of the Organising Committee had been very helpful in the preparation of the Draft Report by writing short review papers which covered a wide range of cosmological topics. The President warmly thanked Drs Zeldovich. Novikov, Nariai, Maccallum and Ne'eman for their efforts.

The following elections were made for the period 1976 to 1979:

President I.D. Novikov

Vice-President G.O. Abell

Organising Committee G. Dautcourt, G de Vaucouleurs, S. Hayakawa, K.I. Kellermann, M.S. Longair, M. Rowan-Robinson and K.S. Thorne.

A long list of proposed new members of the Commission was discussed and with the addition of other names, proposed and seconded by members of the Commission, these proposed new members were elected Commission members. Their names are included in the full list of Commission members which will be found elsewhere in this volume.

The Commission discussed the proposal originating with J. Einasto that an IAU Symposium be cosponsored by the Commissionjointly with Commission No 28 (Galaxies) entitled "The Large Scale Structure of the Universe" to be held in Tallinn, Estonia, USSR in September 1977. The proposal was enthusiastically supported by the Commission members who urge the Executive Committee to view the proposal favourably.

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26 August 1976

SCIENTIFIC SESSION Unconventional and Pathological World Models

The following papers were read:

Y. Ne'eman: Review of Unconventional and Pathological World Models.

B. Carr: Cold and Tepid Universes and Primordial Stars.

V.L. Ginzburg: Black Hole Physics and Fundamental Length.

I. Segal: Chronometric Redshift Theory.

A. Lausberg: Distance Functions for Inertial Interactions in Friedmann Universes.

A. Sapar: The Fundamental Role of Planck Units in Cosmology.

I. Roxburgh: Dirac Cosmology.

J. Barnothy: FIB Cosmology.

28 August 1976

SCIENTIFIC SESSION Classical Cosmological Tests

The following papers were read:

A.S. Webster: The Large Scale Structure of the Universe.

V. Rubin: Criteria for Tests of Isotropy.

M.S. Longair: Survey of Scientific Result of IAU Symposium No 74 "Radio Astronomy and Cosmology".

G. Abell: Mean Matter Density of the Universe as a Cosmological Test

G. de Vaucouleurs: The Distance Scale and H_0.

B. Tinsley: Counts of Galaxies and Related Topics.

K. Matilla: The Background Optical Radiation

J. Solheim: Ghost Images.

W. Tifft: On the Continuity of Redshifts.

30 August 1976

SCIENTIFIC SESSION Galaxy Formation

B. Jones: Review of the Current Status of Theories of Galaxy Formation

M. Anile: Isotropy of the Microwave Background Radiation in Turbulent Cosmologies.

R. Gott: Evolution of the Spectrum of Primordial Density Fluctuations.

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R. Larson: The Collapse and Formation of Galaxies.

I. Novikov: Numerical Calculations of the Non-linear Stages of Galaxy Formation.

There followed a general discussion led by B. Jones during which short contributions were made by B. Lewis, T. Gold, M.J. Rees and I King.

31 August 1976

Joint Discussion No 4 Clusters of Galaxies, Cosmology and Intergalactic Matter

This Joint Discussion was sponsored jointly by Commissions 28 (Galaxies), 47 (Cosmology) and 48 (High Energy Astrophysics). The papers presented at this Joint Discussion will be published in the Volume "Highlights of Astronomy Vol 4". The proceedings are edited by M.S. Longair and J.M. Riley. The programme was as follows:

A. Oemler: The Galaxy Content of Clusters (including a contribution by N. Bahcall on the Structure of Clusters of Galaxies).

S. White: The Dynamical Evolution of Clusters of Galaxies.

R. Gott: Groups of Galaxies.

M. Kalinkov: The Existence of Higher-Order Clusters of Galaxies.

There were also short contributions from J. Dawe, K. Mattila and N. Vidal.

L. Culhane: X-rays from Clusters of Galaxies.

M.S. Longair: Recent Radio Observations of a Complete Sample of Clusters.

D. Harris: Survey of the Radio Properties of Clusters of Galaxies.

S. Lea: Hot Gas in Clusters of Galaxies.

S. Gull: The Microwave Background Radiation in the Direction of Clusters of Galaxies.

There was a short contribution from P.Gorenstein.

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COMMISSION 48: HIGH ENERGY ASTROPHYSICS (ASTROPHYSIQUE DE GRANDE ÉNERGIE)

PRESIDENT: M. J. Rees

BUSINESS MEETING

At a business meeting held on 25th August, the following new organising committee was proposed for Commission 48: I. S. Shklovski (President), F. Pacini (Vice-President), J. Audouze, J. L. Culhane, K. I. Kellermann, L. M. Ozernoi, E. N. Parker, M. J. Rees, J. Shaham. A list of proposed new members of the Commission was also approved.

Two general topics of concern to the Commission were briefly discussed: (i) the possible need for rationalisation of X-ray source nomenclature, and (ii) the desirability of coordinating and exchanging information about transient phenomena recorded in various wavebands.

SCIENTIFIC SESSIONS

25 August 1976

"Physics of dense matter"

(with commission 35)

G. Baym (NORDITA and Illinois)	An overview of neutron star structure; latest developments on equation of state and pion condensation.
J. Shaham (Jerusalem)	Astrophysical consequences of vortex line pinning, wobble, starquakes etc.
N. Holloway (Sussex)	Properties of the surface layers of neutron stars and their relevance to pulsar theories.

(Short contributions were presented by S. Tsuruta (Munich) and K.Brecher (MIT).

26 August 1976

Joint discussion II

"X-ray binaries and compact objects"

(also sponsored by commissions 42 and 44)

G. Clark (MIT)	X-ray bursts
P. J. N. Davison (London)	Periods in X-ray sources
J. Grindlay (Harvard)	Globular cluster sources
A. P. Willmore (Birmingham)	Transient X-ray sources
J. Hutchings (DAO Canada)	Optical observations of X-ray sources
Y. Avni (Weizmann Inst.)	Mass estimates

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E. P. van den Heuvel (Amsterdam)	Evolution of X-ray binaries
Y. Kondo (NASA)	Report on coordinated observations
R. McCray (JILA)	Accretion flows in X-ray binaries

(Short theoretical contributions were presented by F. Lamb (Illinois) R. N. Henriksen (Ontario) and L. Maraschi (Milan).

27 August 1976

"Physics of radio sources and quasars"

(with commission 40)

G. Miley (Leiden)	Radio structure of extended sources
M. S. Longair (Cambridge)	Statistical properties of radio sources
M. Cohen (Caltech)	Compact (VBLI) structure in quasars and galactic nuclei.
D. De Young (NRAO)	Theories of double radio sources
A. Boksenberg (London)	Spectra of quasars and related objects
E. M. Burbidge (La Jolla)	Optical spectra of quasars
J. J. Perry (Munich)	Radiation pressure effects in quasars
S. Colgate (Colorado)	Theories of galactic nuclei involving multiple supernovae
T. Gold (Cornell)	Present status of stellar collision theory
V. L. Ginzburg & L. M. Ozernoi (Moscow)	Theories of galactic nuclei

30 August 1976

"CNO isotopes in astrophysics"

R. N. Clayton (Chicago)	Nucleosynthetic oxygen anomalies in meteorites. Secular variation of the $^{15}N/^{14}N$ ratio in the solar wind.
C. Rolfs (Münster)	New cross section measurements relevant to the CNO nucleosynthesis.
R. Caughlan (Montana)	CNO bi-cycles.
P. Demarque (Yale)	Peculiar CNO abundances in evolved globular clusters
D. Dearborn (Cambridge)	Isotopic abundances in cool stars.
S. Starrfield (Tempe, Arizona)	Nova outbursts and hot CNO cycles.
G. Wannier (Amherst)	Isotopic abundances in dense interstellar clouds.
J. Encrenaz (Meudon)	Isotopic abundances in dense interstellar clouds.
W. Truran (Illinois)	Nucleosynthesis of CNO isotopes.
J. Lequeux (Meudon)	CNO isotopes and chemical evolution of galaxies.
W. Watson (Illinois)	Isotope fractionation in interstellar molecules.
G. Steigman (Yale)	Further comments on fractionation processes in the interstellar medium.

31 August 1976

Joint discussion IV

"Clusters of Galaxies, Cosmology and Intergalactic Matter"

(also sponsored by commissions 28 and 47)

A. Oemler (Yale)	The luminosity function structure and galaxy content of clusters.
J. R. Gott (Princeton)	The formation of clusters of galaxies.
S. White (Cambridge)	The dynamical evolution of clusters by galaxies.
M. Kalinkov (Bulgaria)	The existence of high-order clusters of galaxies.
J. L. Culhane (London)	X-rays from clusters of galaxies.
M. S. Longair (Cambridge)	Statistical properties of radio sources in clusters.
D. Harris (Dwingeloo)	Radio trail sources in clusters.
S. Lea (NASA/Ames)	Hot gas in clusters of galaxies.
S. Gull (Cambridge)	The microwave background in the direction of clusters of galaxies.

(Additional short contributions were presented by J. A. Dawe (Edinburgh) and N. Vidal (Tel Aviv).

1 September 1976

"Supernovae"

D. Branch (Oklahoma)	Supernova observations
L. Rosino (Asiago)	Supernova observations
G. Lasher (I.B.M.)	Supernova light curves
L. Culhane (Mullard, London)	X-rays from supernova remnants
R. Chevalier (Arizona)	Supernova remnants
S. Colgate (Colorado)	Supernovae and quasars
G. Tammann (Basel, Switzerland)	Supernova statistics
B. Tinsley (Yale)	Masses of supernova progenitors
Z. Barkat (Jerusalem)	Evolution of supernova progenitors
J. W. Truran (Illinois)	Explosive nucleosynthesis
K. Sato (Kyoto)	Supernova mechanisms
D. K. Nadyozhin (Moscow)	Gravitational collapse, weak interactions and supernova outbursts
R. Epstein (Harvard and NORDITA)	Gravitational collapse and supernova mechanisms

The full proceedings of Joint Discussions II and IV, edited by E. van den Heuvel and J. M. Riley respectively, will appear, according to custom, in "Highlights of Astronomy". Special arrangements are being made to publish the proceedings of the sessions on "CNO isotopes" and "Supernovae", in two volumes to be edited by J. Audouze and D. N. Schramm.

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COMMISSION 49: THE INTERPLANETARY PLASMA AND THE HELIOSPHERE
(PLASMA INTERPLANETAIRE ET L'HELIOSPHERE)

Report of Meetings, 25 and 26 August 1976

PRESIDENT: W.I. Axford. VICE PRESIDENT: A. Hewish.

The first meeting of Commission 49 was held during the General Assembly on 25 and 26 August 1976. A business meeting was held on the 26 August and new officers were elected as follows:
President: A. Hewish, Vice President: H.J. Fahr, Organizing Committee: S. Grdzielski, A.Z. Dolginov, J.L. Bertaux, S. Cuperman, G. Thomas, W.A. Coles.

It has been agreed that the IAU should co-sponsor the SCOSTEP Symposium on Travelling Interplanetary Phenomena (in memory of the late Dr. L.D. de Feiter), which will be held in Tel Aviv prior to the 20th COSPAR Plenary Meeting in June 1977. It was agreed to seek IAU co-sponsorship of "Solar Wind IV", a specialist meeting on the solar wind which is planned to be held in Germany in September 1978.

25 August 1976

SESSION I: INTERSTELLAR GAS WITHIN THE SOLAR SYSTEM
P. Blum and H.J. Fahr: Neutral gas in the heliosphere
H.J. Fahr: The change of interstellar gas parameters within the solar system
C. Wulf-Mathies: The intensity of the interplanetary helium 584 Å background radiation and the solar line shape at 584 Å
F. Paresce: Resonance absorption cell techniques for the observations of helium in the interstellar wind
C.S. Weller: Present status of and future possibilities for UV measurements of local interstellar gas
J.L. Bertaux: Temporal measurements of neutral hydrogen

SESSION II: INTERPLANETARY SCINTILLATIONS
W.A. Coles: Interplanetary scintillations
N.A. Lotova and I.V. Cheshey: Dispersion analysis of solar wind velocity
S.D. Shawhan, F.T. Erskine, W.M. Cronyn, E.C. Roelof, D.G. Mitchell and B.L. Gotwols: Interplanetary scintillation events associated with solar wind sector boundary crossings at Earth
A. Readhead: Observations of the interstellar medium using interplanetary scintillation

26 August 1976

SESSION III: MISCELLANEOUS TOPICS
M. Dryer, D.S. Intriligator, E.J. Smith, R.S. Steinolfson, J.H. Wolfe and S.T. Wu: Dynamic MHD models of solar-initiated disturbances from the lower corona to 10 AU
H.J. Fahr, H. Ripken and M. Bird: Solar wind expansion from strongly diverging magnetic fields
C.P. Sonett: The moon as a pseudo-scatterer of the interplanetary field

SESSION IV: EXPLORATION OF THE INTERPLANETARY MEDIUM
W.I. Axford: Future possibilities for the exploration of interplanetary space
I. Roxburgh: A solar probe
J.A. Van Allen: Cosmic ray gradient measurements from Pioneers 10 and 11
C. Jordan and D. Bohlin: Solar physics from out-of-ecliptic spacecraft

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COMMISSION 50: IDENTIFICATION AND PROTECTION OF EXISTING AND POTENTIAL OBSERVATORY SITES
(PROTECTION DES SITES D'OBSERVATOIRES EXISTANT ET POTENTIELS)

Report of Meetings, 25 and 30 August 1976

PRESIDENT: M.F. Walker. SECRETARY: P.J. Treanor.

25 August 1976

I. ORGANIZATION

The Commission elected, subject to the approval of the Executive Committee of the Union, the following new officers: President, R. Cayrel; Vice-President, F.G. Smith. The proposed membership of the Organizing Committee was approved by the membership.

II. REVIEW OF CURRENT SITE TESTING PROGRAMS AND EFFORTS TO PROTECT POTENTIAL SITES

The following communications were presented:

F. Sanchez: The Work of the Joint Astronomical Site Survey in the Canary Islands, 1974 - 1975.

F.G. Smith: The British Northern Hemisphere Site Testing Program.

L. Barreto: Observing Sites in Brazil.

G. diTullio: The Italian Site Testing Program.

P.J. Treanor: The Vatican Site Testing Program.

J. Osorio: Observing Sites in Portugal.

B.M. Lewis: Observing Sites in New Zealand.

W. Mattig: JOSO Site Testing Results.

The British Program, conducted by the Royal Observatory Edinburgh and coordinated by B. McInnes, and the Joint Survey directed by F. Sanchez, indicate that good observing conditions exist at Mauna Kea (Hawaii), Izaña (Tenerife), and Fuente Nueva (La Palma)at each of which about 70% of the dark hours are usable and about 60% are photometric. The number of clear hours is somewhat less at Madeira, especially in springtime, the yearly average being about 50% useable and 40% photometric. Fuente Nueva is outstanding for good seeing, about 40% of the useable hours having seeing $\leqslant 1''$. The British Science Research Council has decided that La Palma is the preferred site for the proposed Northern Hemisphere Observatory. A similar conclusion has been reached by JOSO (Joint Organization for Solar Research), who have concluded that the summit of Pico de Teide (Tenerife), and Roque de los Muchachos (La Palma), are the best solar sites within a radius of 3000 km of western Europe. In Spain, a commission has been established with F. Sanchez as President to draft legislation to protect observatory sites on Spanish territory from such adverse factors as light pollution, road construction and air traffic; the IAU, through Commission 50, will be asked to provide criteria and detailed recommendations.

The Italian site testing program was designed to select a site for the 3.5 m national telescope to be located within Italy. Starting in 1960, preliminary tests were made at St. Barthelemy (Valle d'Aosta), Pescopagano (Basilicata), Gravina (Puglia), and M.S. Venere (Sicilia). The best conditions were found at Pescopagano. From July 1972 - December 1973, more detailed observations were made on the mountain Toppo di Castelgrande (altitude 1285 m) located a few kilometers southwest of Pescopagano. During this period, the site had average seeing of $\leqslant 2''$ (as measured by the Polaris trail method) on 65% of the nights, and fair meteorological conditions.

Owing to the artificial brightness of the night sky on the Italian peninsula,

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the search for a new site for the Vatican Schmidt has been concentrated on the island of Sardegna. Considerations of turbulence and access rule out the Gennargentu Mountains and Mount Limbara, while the city of Caglieri (population 350,000) creates a zone of avoidance 60 km in radius. Observations on various high plateaus at about 1000 m altitude reveal the risk of excessive crest cloud and mist. However, Polaris trail and visual observations indicate that seeing adequate for Schmidt camera work, dark sky, and easy access are obtainable below the inversion layer at altitudes of about 600 m. The most promising such region found to date is in central Sardegna in the hills east of Oristano, but more on-site observations of local meteorological conditions are required as the island has a complicated climatic pattern.

Site testing in Portugal has been concerned with the selection of a site within Portugal for the new 76 cm reflector of the University of Porto. From a preliminary study of meteorological records, the mountain of Serra Amarela (1300 m altitude, 30 km from the sea) in the north of Portugal has been selected for on-site study. No results have as yet been obtained.

In June, 1975, the National Committee for Astronomy in New Zealand established a working party to encourage and coordinate site testing activities in New Zealand. Present activities include: construction of instruments to measure sky brightness, seeing, extinction, cloud cover and other meteorological data, and the operation of these instruments at established sites such as the Mount John Observatory (λ = 190° W, ϕ = 44° S, altitude 1029 m) and at various possible sites such as Black Birch (λ = 186° W, ϕ = 41° S, altitude 1400 m). These studies will emphasize seeing measured by recording star trails of Sigma Octantis with polar star trail telescopes of the Lick design, and observations of cloud cover.

III. REVIEW OF CURRENT PROGRAMS TO PROTECT EXISTING OBSERVATORY SITES

The following communications were presented:

R.E. White: Protection of Observatories near Tucson, Arizona.

M.F. Walker: Proposed Light Control Legislation to Protect Lick Observatory.

E.E. Mendoza: Protection of the Site at San Pedro Martir, Baja California.

Z. Suemoto: Protection of Observatory Sites in Japan.

The effect of the lighting control ordinance adopted by the city of Tucson in 1972 (see IAU Inf. Bull. No. 33, 1975) has been to stop the increase of sky illumination with time at Kitt Peak for wavelengths shortward of the λ 4400A cutoff of the filters required for lamps having >15% of their emergent flux shortward of that limit; longward of 4400A, the intensity has continued to increase. Pima County, Arizona, enacted a similar ordinance in May, 1975. This ordinance differs from the former in the creation of special "dark zones," 40 km in radius, around the observatory sites at Kitt Peak, Mt. Lemmon (Catalina Mountains) and Mt. Hopkins (Santa Rita Mountains). Within these zones, lighting is restricted to incandescent type lamps.

The sky brightness at Mount Hamilton is now about four times the natural intensity and the Lick Observatory is therefore attempting to secure lighting control legislation in the surrounding Santa Clara County. As a result of presentations by the Observatory, the Council of Mayors of the cities in Santa Clara County directed the County Association of Public Works Directors to set up a Committee consisting of Public Works Directors, and representatives of the Observatory and the Pacific Gas and Electric Company to study the effect of lighting on the Observatory and recommend solutions. The Committee report found that the work of the Observatory is seriously hampered and will ultimately be rendered impossible unless corrective action is taken. The Committee concluded that it is in the public interest to preserve the scientific capability of the Observatory and to improve lighting efficiency to save energy and money. They therefore have recommended to the cities the adoption of a control ordinance similar to the Tucson city ordinance discussed above, but differing in restricting the types of exterior lighting to incandescent, clear filtered mercury vapor, and low pressure sodium.

The National Astronomical Observatory at San Pedro Martir, Baja California, Mexico, located in the San Pedro Martir Forest Reserve and National Park which covers about 20 x 30 km^2, is protected by a law which states that it is in the public interest to conserve and protect the San Pedro Martir Forest in such a way as to insure the normal development of astronomy and similar sciences.

The protection of three observatory sites in Japan has been arranged through informal contacts between the observatory and the local firms or organizations involved, sometimes assisted by prefecture authorities. It is felt that this type of procedure has been and will be the most effective way of dealing with problems of site protection in Japan. The observatories that have been protected in this way are: the Okayama Astrophysical Station of the Tokyo Astronomical Observatory, which was threatened by lights from the Mizushima and Fukuyama refinery and industrial areas and by lights and vibrations from the new super rapid railway system; as a result of the control programs, the sky brightness due to the industrial areas has remained constant since 1970; the Hida Observatory of the Kyoto University, which was threatened by a searchlight on a bowling alley; the International Latitude Observatory at Mizusawa, threatened by the construction of the super rapid railway and a limited access highway.

IV. PRELIMINARY DISCUSSION OF COMMITTEE RECOMMENDATIONS

After a general discussion of possible recommendations which the Committee might make with regard to site identification and protection, it was decided to appoint a working group on recommendations consisting of Walker, Cayrel, F.G. Smith, Mendoza, and Sanchez to consider these matters and report back to the Commission at the next meeting on 30 August.

30 August 1976

I. RESOLUTION

The Commission approved with emendations the following resolution drafted by the working group on recommendations:

The IAU notes with alarm the increasing levels of interference with astronomical observation resulting from artificial illumination of the night sky, radio emission, atmospheric pollution and the operation of aircraft above Observatory sites.

The IAU therefore urgently requests that the responsible civil authorities take action to preserve existing and planned Observatories from such interference. To this end, the IAU undertakes to provide through Commission 50 information on acceptable levels of interference and possible means of control.

This resolution was submitted for approval and approved by the XVIth General Assembly.

II. COMMISSION RECOMMENDATIONS

On the advice of the working group on recommendations, the Commission decided to make only the following general recommendations at this time:

(1) The Commission considers that the most vital problem is that of preserving those sites known to have a very high quality from adverse conditions of all kinds. The most urgent aspect is to limit artificial illumination to a small fraction of the natural sky brightness, making these sites available for observations of faint objects that cannot be made in any other way. The Commission therefore urges astronomers and civil authorities to give highest priority to this problem.

(2) The Commission recommends that at existing observatories where a more limited range of observations can be made despite considerable levels of light pollution, every effort should be made to prevent these levels from increasing.

(3) The Commission recommends that the power of radio transmitters be limited so as to avoid interference with sensitive electronic detectors. Present experience suggests that to avoid interference with electronic equipment used on optical telescopes, the power flux from radio transmitters should not exceed one millivolt per meter (or 1.6 microwatts per square meter) at the observatory site. (Note that this value supercedes that given in the Report of Commission 50, Trans. IAU XVIa).

(4) The Commission recommends that aircraft routes be planned to avoid the skies over observatory sites, so as to prevent interference by condensation trails. Restriction of this nature would involve flights at altitudes of $\geq 10°$ as seen from the sites, which implies that civil air lanes should be placed at least 60 km from sites of very high quality. An example of the effectiveness of this type of restriction was reported by Cayrel: all air traffic over Haute Provence was banned for the total solar eclipse of 1961 February 15. The sky remained clear, but when air traffic was resumed in the afternoon, clouds were generated by the aircraft trails.

III. WORKING GROUP

Detailed recommendations will require considerably more study than was possible during the course of the General Assembly. For example, the provisions of recommendations (1) and (2), above, will clearly be different for different locations. In order to develop the specific recommendations called for in the resolution, the Commission voted to establish a working group which will, in consultation with all members of the Commission, study these matters in depth and report back to the Commission in about one year. This group will consist of Cayrel, F.G. Smith, Walker, Sanchez, White, and an additional member from the USSR to be appointed by the USSR Academy of Sciences. The working group will draft specific recommendations with regard to the identification of potential sites as well as the protection of these and existing locations.

IV. DISCUSSION OF SPECIFIC SITES

Regarding specific sites, the Commission noted that research on island sites with suitable latitude, airmass conditions, and altitude of peak has narrowed these down to a very small number, including notably Guadaloupe, the Canary Islands, Madeira, Pico, and Hawaii.

Observations by the British observers covering 17 months show that Madeira is a good site, only slightly inferior to the Canary Islands. Osorio emphasized that there is an urgent need for light control legislation on Madeira to prevent the illumination from reaching a harmful level. The Commission resolved to inform the Portugese authorities, through the Secretary General, that the Commission considers the Madeira site of high quality, worthy of protection, and in urgent need of legislation in view of the present light pollution danger.

Less is known about Pico, which is a volcanic cone promising laminar air flow. Osorio reported that the Portugese meteorological authorities are willing to collaborate in improving meteorological data for the peak, and that the Portugese astronomers are willing to assist in astronomical observations in site testing on Pico. The Commission expressed the view, to be communicated to the Portugese authorities, that it would be desirable to initiate a preliminary program of meteorological observations on Pico.

IV. OTHER COMMISSION ACTIVITIES

In addition to the matters discussed above, the Commission decided:

(1) That the next President of Commission 50 shall expand the existing contacts with Commission 42 and the Inter-Union Commission on Frequency Allocations for Radio Astronomy and Space Science, and initiate an exchange of documents.

(2) That closer relationships shall be established with JOSO and the question of expanding the activities of the Commission to include solar astronomy will be explored.

(3) That to fulfill its role as a clearing house of information, the Commission will request site testing groups and institutions active in site protection to send copies of relevant documents to the President. Arrangements will be made by F.G. Smith to set up an archive of this material at Herstmonceux. The Commission will prepare and distribute to Commission members and other interested individuals index lists of available documents and published references.

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WORKING GROUP FOR PLANETARY SYSTEM NOMENCLATURE

NOMENCLATURE DU SYSTÈME PLANÉTAIRE

PRESIDENT: P. M. Millman

At the XV General Assembly of the International Astronomical Union in Sydney, Australia, August 21-30, 1973, a new working group was formed, the Working Group for Planetary System Nomenclature (IAU/WGPSN). Unlike most other working groups in the IAU the WGPSN does not report through any commission, or group of commissions, but is responsible only to the Executive Committee of the IAU, and reports directly to this Committee. The WGPSN is charged with formulating and coordinating all topographic nomenclature on the planetary bodies of the solar system and has certain powers of action in the interval between General Assemblies. The establishment of the WGPSN was found advisable because of the recent rapid advance in our knowledge of the topography of the surfaces of planetary bodies, and the necessity of coordinating the approved systems of nomenclature among the different planets and their satellites.

In the period 1973-1976 the WGPSN held three meetings as follows:-

First Meeting - Ottawa, Canada, June 27 and 28, 1974;
Second Meeting - Moscow, USSR, July 14 and 18, 1975;
Third Meeting - Grenoble, France, August 30 and 31, 1976.

The following members of the IAU have served on the WGPSN in the interval noted:-

A. Dollfus	D. Morrison
B.Ju. Levin	T.C. Owen
C.H. Mayer	G.H. Pettengill
D.H. Menzel	S.K. Runcorn
P.M. Millman	B.A. Smith

In addition to those listed above, the following have been members of the various nomenclature task groups, responsible for compiling the detailed material to be presented to the WGPSN:-

K. Aksnes	I.K. Koval
M.S. Bobrov	A.D. Kuz'min
C.R. Chapman	Yu.N. Lipskij
M.E. Davies	M.Ya. Marov
F. El-Baz	H. Masursky
K.P. Florenskij	S. Miyamoto
D. Gautier	A.V. Morozhenko
O.J. Gingerich	C. Sagan
R.M. Goldstein	V.V. Shevchenko
J.E. Guest	V.G. Tejfel'

The nomenclature resolutions passed by the WGPSN, and later approved by the International Astronomical Union, are listed in the following pages.

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First Meeting

Resolutions from the First Meeting of the I.A.U. Working Group for Planetary System Nomenclature, Ottawa, Ontario, June 27 and 28, 1974.

Resolution I

BASIC PRINCIPLES FOR PLANETARY SYSTEM NOMENCLATURE

(a) Nomenclature is a tool and the first consideration shall be to make it simple, clear and unambiguous.

(b) The number of names chosen for each body should be kept to a minimum, and governed by the anticipated requirements of the scientific community.

(c) Although there will be exceptions, duplication of the same name on two or more bodies should be avoided.

(d) In general, individual names chosen should be single words, and expressed in the language of origin. Transliteration and pronunciation for various alphabets should be given, but there will be no translation from one language to another.

(e) Where possible, consideration should also be given to the traditional aspects of any nomenclature system, provided that this does not cause confusion.

(f) Solar system nomenclature shall be international in its choice of names. Recommendations submitted by I.A.U. National Committees will be considered. Final approval of any selection is the responsibility of the International Astronomical Union.

(g) We must look to the future in general discussions of solar system nomenclature and attempt to lay the groundwork for future requirements that will result from the development of the space program.

Resolution II

LATIN TERMS FOR DIFFERENT TYPES OF FEATURES, TO BE USED IN PLANETARY SYSTEM NOMENCLATURE

The following Latin terms, already approved for use on the moon or Mars, are suitable for use with a nomenclature system on any planet or satellite in the solar system (plurals are given in brackets):-

Latin Term	Approximate Description
(a) CATENA (Catenae)	a chain or line of craters
(b) CHASMA (Chasmata)	a deep, elongated, steep-sided depression
(c) CRATER (Crateres)	an essentially circular depression
(d) DORSUM (Dorsa)	a ridge
(e) FOSSA (Fossae)	a long, narrow, shallow depression
(f) LABYRINTHUS (Labyrinthi)	a complex of intersecting narrow depressions
(g) MENSA (Mensae)	a flat-topped prominence with cliff-like edges
(h) MONS (Montes)	a mountain
(i) PATERA (Paterae)	an irregular crater, or a complex one with scalloped edges
(j) PLANITIA (Planitiae)	a plain
(k) PLANUM (Plana)	a plateau
(l) RIMA (Rimae)	a fissure
(m) RUPES (Rupes)	a scarp

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Latin Term	Approximate Description
(n) THOLUS (Tholi)	a hill
(o) VALLIS (Valles)	a valley
(p) VASTITAS (Vastitates)	an extensive plain

When required, additional Latin terms may be added to this list, but it is recommended that the number of terms used be kept to a minimum. The following terms, already in use on the moon, should be discussed in each case before being used on other planetary bodies:-

(q) LACUS (Lacus)
(r) MARE (Maria)
(s) PALUS (Paludes)
(t) PROMONTORIUM (Promontoria)
(u) SINUS (Sinus)

Resolution III

POSSIBLE NAME CATEGORIES FOR USE IN PLANETARY SYSTEM NOMENCLATURE

Traditionally, the names of distinguished, deceased scientists have generally been used to name craters on the moon and Mars. Although this source can still be used it is obvious, when we examine the future requirements of planetary system nomenclature, and particularly for the case of the other planets and satellites, that we should consider the possibility of using additional name categories.

Recommendations concerning the name categories for any planet and its satellites shall be approved by the Working Group for Planetary System Nomenclature before the individual names are assigned by the Task Group concerned. Task groups shall operate in compliance with Resolution I. It is agreed to prohibit the assignment of names of individuals known primarily

- as religious figures;
- as military leaders, political leaders, and philosophers of the 19th and 20th centuries.

Some examples of name categories that can, without difficulty, provide several hundred names, and in some cases considerably more, are:-

(a) distinguished, deceased - artists (painters)
(b) distinguished, deceased - muscians
(c) distinguished, deceased - sculptors
(d) distinguished, deceased - writers and poets

Where names of specific individuals are used the dates of birth and death, and very brief biographical details, should be published.

(e) animals
(f) birds
(g) cities
(h) first names of men and women
(i) islands
(j) lakes
(k) minerals
(l) mountains
(m) rivers
(n) villages

Some examples of name categories capable of providing less than one hundred names are:-

(o) deserts
(p) fundamental particles
(q) geographical provinces
(r) observatories
(s) scientific instruments
(t) ships of discovery
(u) the name of the particular planet or satellite in various languages

The preceding lists should in no way be considered restrictive.

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Eventually, we may have to consider the surface nomenclature for a total of more than thirty different planetary bodies. Hence, the choice of name categories should be made with this in mind.

Resolution IV

SCHEDULES FOR MAP PRODUCTION

The development of lists of names for various bodies in the solar system is an important but time-consuming task that must involve a cooperative effort by representatives of several countries. To avoid decisions hastily made to satisfy contractual deadlines or mission constraints, it is essential that the nomenclature task groups be made aware of these requirements well in advance.

We therefore request the Executive Committee of the I.A.U. to notify those organizations that may be responsible for production of maps of solar-system bodies (e.g. NASA), asking them to inform the IAU/WGPSN of any plans for mapping that will involve deadlines for the availability of names. The IAU/WGPSN should also receive advance notice of any missions that may involve landing sites or areas of reconnaissance requiring special nomenclature.

Resolution V

ADVANCE NOTICE OF MEETINGS

Working Group meetings and Task Group meetings should be scheduled at least six months in advance, if at all possible. When convenient, such meetings might be scheduled in conjunction with international meetings which a majority of members are likely to attend.

Resolution VI

PROCEDURES IN TASK GROUPS

Task-group members unable to attend meetings shall be contacted by the Chairman regarding concurrence in the choice of names. Adequate documentation shall be provided. Lack of response within 45 days (allowed for two-way mail or wire service) shall be regarded as concurrence.

Resolution VII

LUNAR MAPPING

Until the next meeting of the IAU/WGPSN, approximately one year from June, 1974, names of non-scientists shall not be chosen for lunar maps.

Resolution VIII

NOMENCLATURE FOR MERCURY

(a) The classical nomenclature, as used by E.M. Antoniadi, will be adopted for regional names and albedo features but probably not for topographic features.

(b) A maximum of six features will be named for deceased scientists who have made exceptional contributions to the study of this planet.

(c) The craters may be named for birds of the world, or for cities of the world.

(d) Other features may be named for (i) ships of discovery, (ii) names of Mercury or associated with Mercury in various languages, (iii) observatories.

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(e) A shorthand notation, similar to that used for Mars, will be sought as a potential means for designating small craters on Mercury.

(f) A Latin term will be chosen for the class of geological feature called in English a "basin".

(g) The following three names, already in provisional use, are approved:-

Kuiper
Caloris
Hun kal

Resolution IX

NOMENCLATURE FOR MARS

The names Kuiper and Vishniac are approved for craters at the following locations:-

Kuiper, G.P.	long.	157	lat.	-57
Vishniac, W.		275		-76

Resolution X

NOMENCLATURE FOR MARS

On the 1:1,000,000 and 1:250,000 series maps of Mars a system is proposed for naming the previously undesignated craters of approximately 5-20 km diameter, and craters 20-100 km in size which have double-letter designations. Names for these craters have been chosen from a list of small towns and villages of the world. Criteria used in compiling the list of names were - (i) names of three or less syllables which are easy to pronounce, (ii) worldwide representation, (iii) names limited to small towns or villages. Two and three syllable names are proposed for 10-20 km undesignated craters and 20-100 km double-lettered craters on the 1:1,000,000 maps; one syllable names are proposed for very small (5-10 km) craters on the 1:250,000 maps. We do not propose at the present time to name the other 6000 double-lettered craters on Mars, but feel that, within the small landing site areas, named craters would be more meaningful as reference points than lettered craters.

Second Meeting

Resolutions from the Second Meeting of the I.A.U. Working Group for Planetary System Nomenclature, Moscow, USSR, July 14 and 18, 1975.

Resolution I

LUNAR NOMENCLATURE

1. (a) For sheets of the 1:250,000 lunar map series we recommend that where old lettered crater names (Mädler system names) are replaced by approved new names, the old names be printed on the map in brackets under the new names.

   (b) For Edition 3 of the 1:5,000,000 lunar map series we recommend retention of all the lettered crater names now present on Edition 2. Where these lettered craters have been assigned approved new names the old name will be shown in brackets on the map under the new name.

2. For the 1:1,000,000 lunar map series (LAC) we recommend the following sheet names:-

LAC No.	Name	LAC No.	Name
1	Peary	51	Cockcroft
2	Carpenter	52	Joule
3	Anaxagoras	53	Fersman
4	Meton	54	Robertson
5	Petermann	55	Vasço da Gama
6	Schwarzschild	56	Hevelius
7	Karpinskij	57	Kepler
8	Kirkwood	58	Copernicus
9	Brianchon	59	Mare Vaporum
10	Pythagoras	60	Julius Caesar
11	J. Herschel	61	Taruntius
12	Plato	62	Mare Undarum
13	Aristoteles	63	Neper
14	Endymion	64	Babcock
15	Belkovich	65	Ostwald
16	Compton	66	Mendeleev
17	Störmer	67	Mandel'shtam
18	D'Alembert	68	Sharonov
19	Birkhoff	69	Zhukovskij
20	Coulomb	70	Kibalchich
21	Omar Khayyam	71	Michelson
22	Lavoisier	72	Nobel
23	Rümker	73	Riccioli
24	Sinus Iridum	74	Grimaldi
25	Cassini	75	Letronne
26	Eudoxus	76	Montes Riphaeus
27	Geminus	77	Ptolemaeus
28	Gauss	78	Theophilus
29	Fabry	79	Colombo
30	Millikan	80	Langrenus
31	Campbell	81	Ansgarius
32	Chandler	82	Pasteur
33	Schneller	83	Langemak
34	Fowler	84	Dellinger
35	Landau	85	Keeler
36	Lorentz	86	Icarus
37	Russell	87	Korolev
38	Seleucus	88	Vavilov
39	Aristarchus	89	Lucretius
40	Timocharis	90	Lowell
41	Montes Apenninus	91	Eichstadt
42	Mare Serenitatis	92	Byrgius
43	Macrobius	93	Mare Humorum
44	Cleomedes	94	Pitatus
45	Hubble	95	Purbach
46	Joliot	96	Rupes Altai
47	Seyfert	97	Fracastorius
48	Mare Moscoviense	98	Petavius
49	Komarov	99	Humboldt
50	Fitzgerald	100	Hilbert

LAC No.	Name	LAC No.	Name
101	Fermi	121	Apollo
102	Gagarin	122	Brouwer
103	O'Day	123	Rydberg
104	Van de Graaff	124	Phocylides
105	Mohorovicic	125	Schiller
106	Lodygin	126	Clavius
107	Houzeau	127	Hommel
108	Mare Orientale	128	Biela
109	Vallis Inghirami	129	Lyot
110	Schickard	130	Fechner
111	Wilhelm	131	Planck
112	Tycho	132	Hess
113	Maurolycus	133	Minkowski
114	Rheita	134	Fizeau
115	Furnerius	135	Arrhenius
116	Mare Australe	136	Bailly
117	Milne	137	Moretus
118	Jules Verne	138	Manzinus
119	Mare Ingenii	139	Helmholtz
120	Oppenheimer	140	Schrödinger
		141	Minnaert
		142	Zeeman
		143	Hausen
		144	Amundsen

3. We recommend the approval of the following list of crater names as assigned on the moon:-

AL-KHWARIZMI	780-850? Arab mathematician	7.0 N, 107.0 E
ARTSIMOVICH (Lev A.) (replaces Diophantus A)	1909-1973 Russian Physicist	27.5 N, 36.5 W
AVERY (Oswald T.) (replaces Gilbert U)	1877-1955 Canadian Biologist	1.2 S, 81.3 E
BACK (Ernst E.A.) (replaces Schubert B)	1881-1959 German physicist	1.2 N, 80.6 E
BLACK (Joseph) (replaces Kästner F)	1728-1799 French chemist	9.0 S, 80.4 E
BOREL (Félix Édouard Émile) (replaces Le Monnier C)	1871-1956 French mathematician	22.7 N, 26.4 E
CAVENTOU (Joseph Bienaimé) (replaces La Hire D)	1795-1877 French cehmist	29.8 N, 29.3 W
DALE (Henry Hallett)	1875-1968 (Nobel, 1936) English Physiologist	9.4 S, 83.0 E
ELMER (Charles W.)	1872-1954 American amateur astronomer	10.0 S, 84.2 E
ESCLANGON (Ernest B.) (replaces Macrobius L)	1876-1954 French astronomer	21.5 N, 42.0 E

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FREDHOLM (Erik Ivar) (replaces Macrobius D)	1866-1927 Swedish mathematician	18.5 N, 46.5 E
GARDNER (Irvine Clifton) (replaces Vitruvius A)	1889-1972 American physicist	17.7 N, 33.7 E
GAST (Paul W.)	1930-1973 American geochemist	Dorsum near 24 N, 9 E
GOLGI (Camillo) (replaces Schiaparelli D)	1843-1926 (Nobel, 1906) Italian cytologist	27.8 N, 59.9 W
GREAVES (William M.H.) (replaces Lick D)	1897-1955 British astronomer	13.2 N, 52.6 E
HELMERT (Friedrich Robert)	1843-1917 German geodicist-astronomer	7.5 S, 87.7 E
ISAEV (Aleksej M.)	1908-1971 Russian rocket engineer	17.5 S, 147.5 E
KROGH (Schack August Steenberg) (replaces Auzout B)	1874-1949 (Nobel, 1920) Danish physiologist	9.7 N, 65.8 E
LANDSTEINER (Karl) (replaces Timocharis F)	1868-1943 (Nobel, 1930) Austrian/American pathologist	31.2 N, 14.9 W
LEBESGUE (Henri Leon)	1875-1941 French mathematician	5.1 S, 89.0 E
LIOUVILLE (Joseph)	1809-1882 French mathematician	4.2 N, 73.7 E
McADIE (Alexander George)	1863-1943 American meteorologist	2.0 N, 92.4 E
McDONALD (W. Johnson) (replaces Carlini B)	1844-1926 American amateur astronomer	30.4 N, 21.0 W
MORLEY (Edward Williams) (replaces MacLaurin R)	1838-1923 American chemist	2.8 S, 64.6 E
NECHO	610-593 B.C. Egyptian geographer	5.0 S, 123.0 E
POMORTSEV (Mikhail M.) (replaces Dubiago P)	1851-1916 Russian rocket scientist	0.7 N, 67.0 E
PUPIN (Michael I.) (replaces Timocharis K)	1858-1935 Yugoslavian/American physicist	23.8 N, 11.0 W
RAMAN (Chandrasekhara V.) (replaces Herodotus D)	1888-1970 (Nobel, 1930) Indian physicist	27.0 N, 55.2 W
RESPIGHI (Lorenzo) (replaces Dubiago C)	1824-1890 Italian astronomer	4.0 N, 72.0 E
RUTHERFORD (Ernest)	1871-1937 (Nobel, 1908) English physicist	10.5 N, 137.0 E
SAMPSON (Ralph Allen)	1866-1939 British astronomer	29.7 N, 16.7 W
SANTOS-DUMONT (Alberto) (replaces Hadley B)	1873-1932 Brazilian pioneer in aeronautics	27.7 N, 4.8 E
SCHEELE (Carl Wilhelm) (replaces Letronne D)	1742-1786 Swedish chemist	9.5 S, 38.0 W

SHERRINGTON (Charles Scott)	1856-1952 (Novel, 1932) English neurophysiologist	11.0 S, 117.5 E
SLOCUM (Frederick)	1873-1944 American astronomer	3.0 S, 89.0 E
STEWARD (John Quincy) (replaces Dubiago Q)	1894-1972 American astronomer	2.2 N, 67.0 E
SWASEY (Ambrose)	1846-1937 American inventor	5.5 S, 89.7 E
SWIFT (Lewis) (replaces Peirce B)	1820-1913 American astronomer	19.4 N, 53.5 E
TALBOT (William Henry Fox)	1800-1877 English chemist	2.3 S, 85.3 E
TOSCANELLI (Paolo dal Pozza) (replaces Aristarchus C)	1397-1482 Italian physician, map-maker	27.9 N, 47.6 W
TOWNLEY (Sidney Dean) (replaces Apollonius G)	1867-1946 American astronomer	3.8 N, 63.2 E
VAN ALBADA (Gale Bruno) (replaces Auzout A)	1912-1972 Dutch astronomer	9.8 N, 64.5 E
VAN VLECK (John Monroe) (replaces Gilbert M)	1833-1912 American mathematician, astronomer	1.4 S, 78.2 E
WARNER (Worcester Reed)	1846-1929 American inventor	3.9 S, 87.3 E
WEIERSTRASS (Karl Theodor W.) (replaces Gilbert N)	1815-1897 German mathematician	0.9 S, 72.3 E
ZASYADKO (Alexander D.)	1779-1837 Russian rocket scientist	3.8 N, 94.0 E

4. We recommend the approval of the following list of first names of men and women for use as crater names in restricted areas of the moon:-

Agnes
Akis
Alan
Aloha
André
Ango
Ann
Annegrit
Ardeshir
Artemis

Bawa
Béla
Brigitte

Carlos
Carmen
Chang-ngo
Charles
Ching-te
Christel
Cleopatra
Courtney

Dag
Delia
Dieter
Dilip

Edith

Fairouz
Felix

Ganau

Harold

Ian
Ina
Isis
Ivan

Jehan
Jerik
Jomo
José
Julienne

Karima
Kathleen
Kira
Krishna

Manuel
Marcello
Mary
Mavis
Michael
Monira
Natasha

Osama
Osiris
Osman

Patricia
Pierre
Priscilla

Ravi
Reiko
Robert
Rocco
Rosa
Rudolf
Ruth

Siegfried
Sita
Soraya
Stella
Sung-mei
Susan

Taizo
Thera

Vera
Verne
Vladimir

Wan-yu

Yoshi
Yuri

Zahia

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5. (a) We recommend that the following list of generic Latin terms be used henceforth in assigning names to non-crater features on the moon:-*

Catena	Mons	Rupes
Dorsum	Planum	Sinus
Lacus	Promentorium	Tholus
Mare	Rima	Vallis

(b) We recommend that the following generic Latin term be retained where presently assigned on the moon but not be used in the future assignment of names:-†

Palus

6. In three exceptional cases we recommend the adoption of the following names, already in use on the moon:-

Reiner Gamma
Mons Hadley Delta
Mons Maraldi Gamma

Resolution II

MERCURY NOMENCLATURE

1. We recommend approval for the following names for features on Mercury, all of which have been assigned by the Mercury Nomenclature Task Group to specific features:

PLANITIA

Borealis
Budh
Odin
Sobkou
Suisei
Tir

MONTES

Caloris

DORSUM

Antoniadi
Schiaparelli

RUPES

Astrolabe
Discovery
Endeavour
Fram
Heemskerck
Hero
Mirni
Santa María
Victoria
Vostock

VALLIS

Arecibo
Goldstone
Haystack
Simeiz

*It was felt that for the terms Lacus, Mare, Planum, Promontorium, Sinus and Tholus, there should be a case by case discussion before using them with new names.

†It was recognized that the term Oceanus was suitable for use in its present application on the moon but that there was little likelihood of the need for this term in conjunction with new names.

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2. We recommend approval of the following bank of names to be applied as needed to Rupes on Mercury:

Adventure	Gjöa	Persej	Resolution	Zarya
Beagle	Kon Tiki	Pinta	São Gabriel	Zeehaen
Endurance	Niña	Pourquoi-Pas	Vityaz'	

3. We propose approval for the names on the attached map of albedo features observed telescopically. These names can be used for albedo features only, and are provided at this time for use by telescopic observers (see page 332 for map).

4. For the initial 1:5,000,000 topographic maps of the parts of Mercury photographed by Mariner 10, we suggest that map sheets be assigned dual names. The first sheet name will be that of a prominent topographic feature, and the second name, to be placed in parentheses, will be that of an albedo feature as indicated (see page 333 for map).

Resolution III

VENUS NOMENCLATURE

1. It is proposed that two themes, particularly appropriate for Venus, be adopted as a source of names for surface features. The more important of these themes derives from the feminine mystique long associated with Venus, and it is proposed that all craters received feminine names. Basins and extended basin-like plains (i.e. like Mare Imbrium on the moon and Hellas on Mars) are to be given names of goodesses from ancient cultures. Craters larger than about 100 km in diameter (the actual size will depend on the number of large craters found) should be assigned female names drawn from mythology, while craters of smaller diameter would receive feminine first names drawn from all cultures. The lowest crater size limit to be named cannot be specified in advance of observations.

2. The second of these themes derives from the extensive and opaque cloud cover which surrounds the planetary sphere, and which requires the use of radio and other techniques in order to study and map the solid surface. It is, therefore, proposed to assign the names of deceased radio, radar and space scientists to topographic features. These features will be described using the classes and corresponding latin names as defined for the moon and Mars where applicable.

3. An exception to the above themes is proposed in the case of a single prominent surface feature which was among the first to be observed, and which has served to help define the origin of the official IAU system of longitudes for the planet. This feature, some 1000 km in diameter, is located at approximately -25° latitude and 0° longitude. It is proposed that this feature be called Alpha.

Resolution IV

MARS NOMENCLATURE

We recommend that the following actions be accepted:

1. Add the following terms to describe specific topographic features on Mars:

Chaos	- distinctive areas of broken terrain
Cavus (plural, Cavi)	- hollows, irregular steep-sided depressions usually in arrays or clusters

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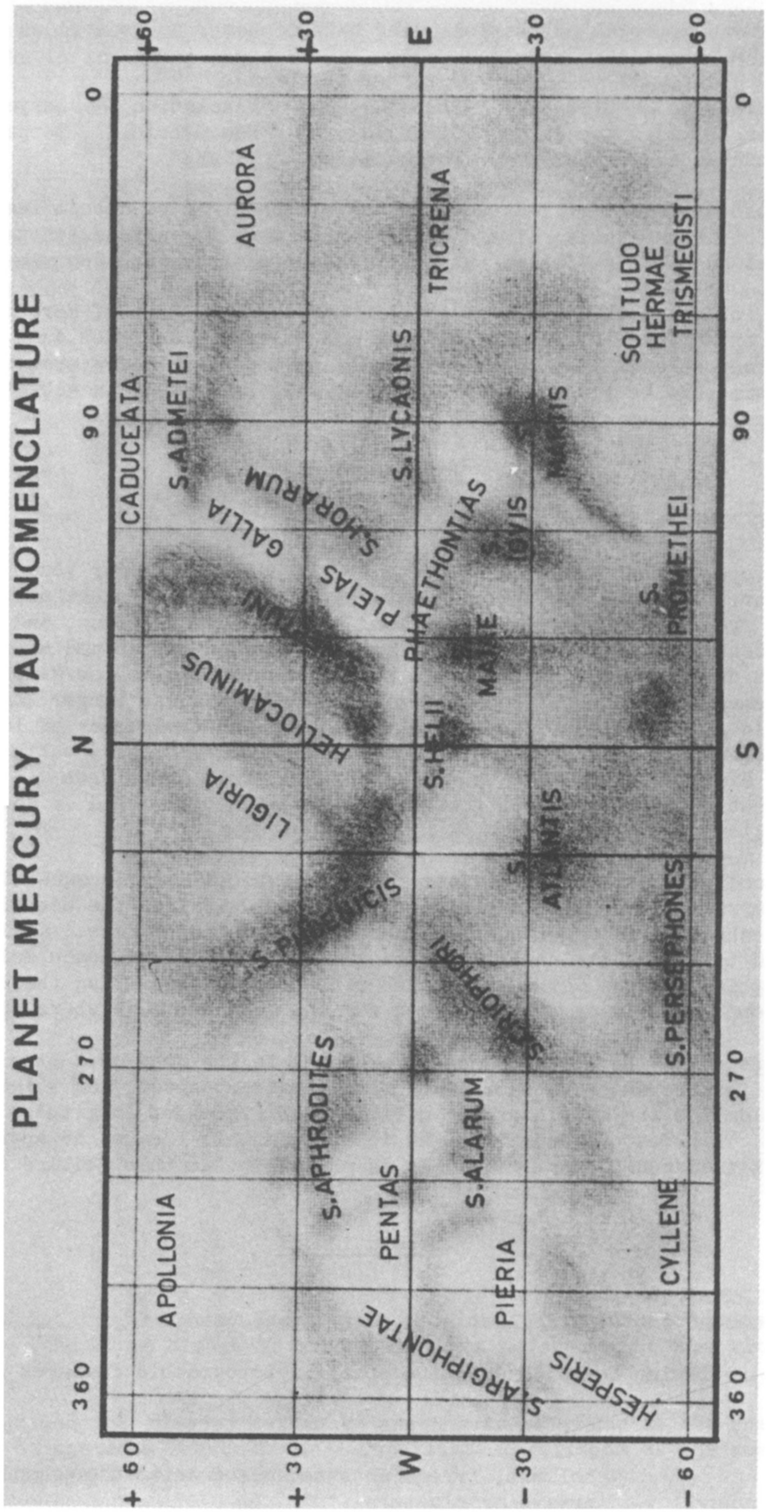

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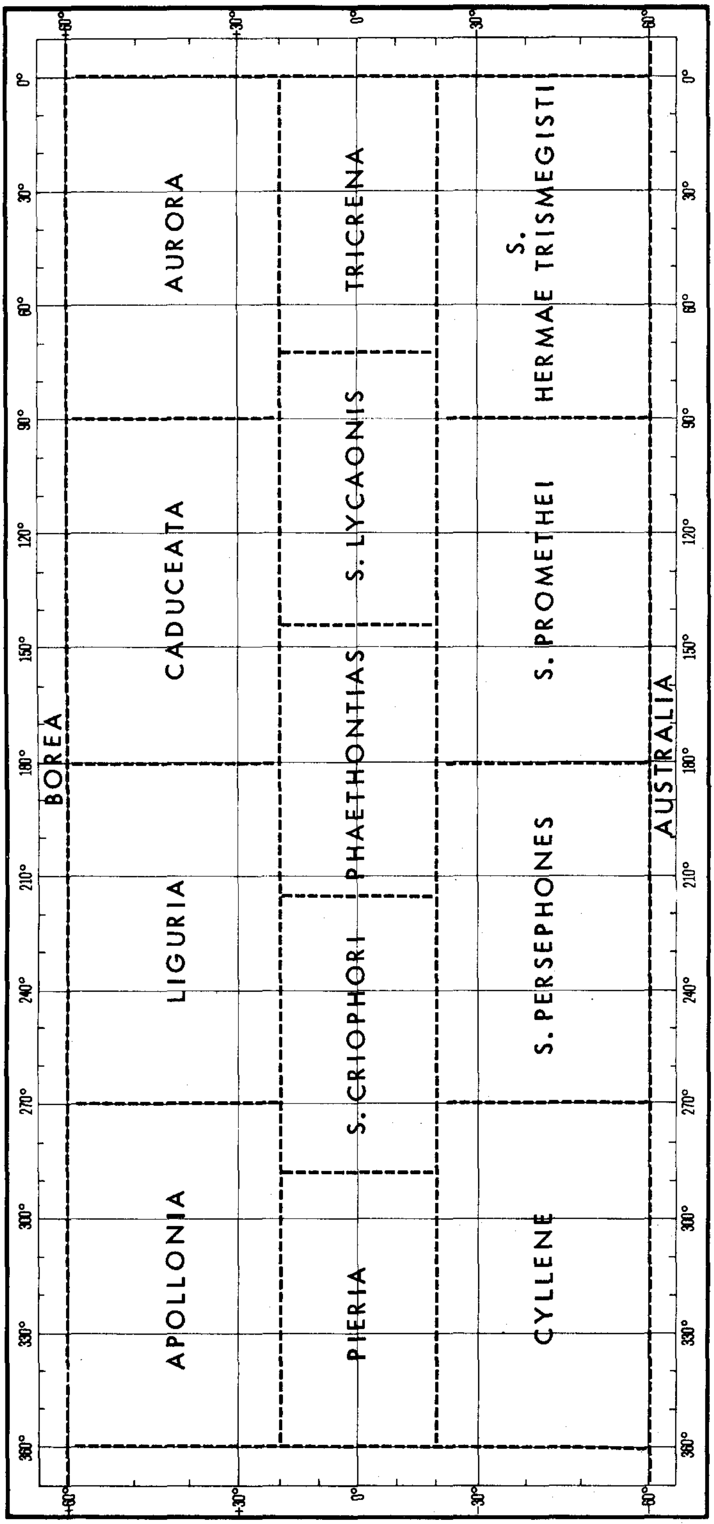
BOREA
AURORA
CADUCEATA
LIGURIA
APOLLONIA
TRICRENA
S. LYCAONIS
PHAETHONTIAS
S. CRIOPHORI
PIERIA
S. HERMAE TRISMEGISTI
S. PROMETHEI
S. PERSEPHONES
CYLLENE
AUSTRALIA

2. Use the names of terrestrial rivers of countries throughout the world for small valleys and channels on Mars.

3. Add the following names to the Mars charts, 1:5,000,000 series:

Sheet		Longitude W	Latitude
MC 1	Rupes:		
	Hyperboreus Rupes	60° to 160°	+80° to +85°
	Frigoris Rupes	20° to 305°	+80°
	Planum:		
	Borea Planum	circumpolar	+80° to +90°
MC 4	Mensa:		
	Siloe Mensae	10° to 20°	+30° to +40°
	Rupes:		
	Nilokeras Rupes	40° to 52°	+32° to +40°
MC 8	Dorsum:		
	Eumenides Dorsum	156° to 158°	0° to +10°
	Gordii Dorsum	142° to 146°	+ 1° to + 7°
	Rupes:		
	Olympus Rupes	130° to 138°	+15° to +23°
MC 9	Catena:		
	Tractus Catena	103° to 104°	+20° to +35°
MC 10	Chasma:		
	Echus Chasma	80° to 82°	0° to + 7°
	Vallis:		
	Nanedi Vallis	50°	0° to + 7°
MC 11	Chaos:		
	Aram Chaos	20° to 24°	0° to + 5°
	Hydaspis Chaos	25° to 30°	+ 1° to + 4°
	Hydraotes Chaos	32° to 37°	0° to + 3°
MC 13	Dorsum:		
	Arena Dorsum	291° to 294°	+10° to +16°
	Patera:		
	Nepenthes Patera	271°	+12°
	Rupes:		
	Phison Rupes	308° to 310°	+26° to +27°
	Arena Rupes	289° to 291°	+11° to +16°
MC 17	Fossa:		
	Aganippe Fossa	128° to 129°	- 4° to -11°
MC 18	Dorsum:		
	Felis Dorsum	63° to 70°	-20° to -27°
	Melas Dorsum	70° to 75°	-15° to -23°
	Solis Dorsum	79° to 85°	-21° to -27°

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Sheet		Longitude W	Latitude
MC 19	Chaos:		
	Margaritifer Chaos	17° to 22°	- 7° to -11°
	Fossa:		
	Erythraea Fossa	29° to 32°	-28° to -29°
	Vallis:		
	Samara Valles	18° to 20°	-22° to -26°
	Ladon Valles	27° to 30°	-21° to -24°
	Uzboi Vallis	34°	-26°
MC 26	Fossa:		
	Oceanidum Fossa	27° to 31°	-60° to -63°
	Rupes:		
	Bosporos Rupes	53° to 60°	-39° to -47°
	Ogygis Rupes	53° to 55°	-33° to -35°
	Tholus:		
	Charitum Tholus	41°	-55°
MC 30	Dorsum:		
	Argentea Dorsum	15° to 40°	-76° to -80°
	Brevia Dorsa	280° to 310°	-68° to -73°
	Planum:		
	Australis Planum	circumpolar	-80° to -90°
	Rupes:		
	Promethei Rupes	230° to 315°	-16° to -80°
	Hypernotius Rupes	185° to 250°	-19° to -83°
	Ultimi Rupes	200°	-65° to -77°
	Chasma:		
	Thyles Chasma	230° to 235°	-69° to -73°
	Cavi:		
	Angusti Cavi	60° to 90°	-70° to -84°
	Sisyphi Cavi	340° to 0°	-76° to -82°
	Cavi Novi	320° to 340°	-66° to -70°
	Ultimi Cavi	195° to 210°	-73° to -75°

4. Change Pavonis Patera to Ullyses Patera 121°.5 +3°.

5. The following names for the Viking Landing Site Maps are proposed:

Cydonia Region	Longitude W	Latitude	Country of Origin
Apt	9°.5	+40°.1	France
Arandas	15.1	+42.6	Mexico
Banberg	3.1	+39.9	West Germany
Can	14.6	+48.4	Turkey
Cray	16.2	+44.4	U.K.(England)
Eagle	8.2	+44.0	USA
Eil	9.7	+42.0	Somalia
Elath	13.7	+46.1	Israel
Esk	7.0	+45.4	Australia
Faith	11.9	+43.2	USA
Freedom	9.0	+43.6	USA
Garm	9.2	+48.4	USSR

Cydonia Region	Longitude W	Latitude	Country of Origin
Gol	10°.7	+47°.4	Norway
Hope	10.3	+45.1	Canada
Jen	10.6	+40.1	Nigeria
Laf	5.9	+48.3	Cameroon
Lagarto	8.4	+50.2	Brazil
Land	8.8	+48.4	USA
Lota	11.9	+46.5	Chile
Mohawk	5.4	+43.2	USA
Tem'	9.5	+42.1	USSR
Vils	11.7	+39.2	Austria
Yakima	3.2	+43.3	USA
Chryse Region			
Batoş	29.5	+21.7	Romania
Bled	31.4	+21.8	Yugoslavia
Bok	31.6	+20.8	New Guinea
Cave	35.6	+21.9	New Zealand
Concord	34.1	+16.9	USA
Gold	31.3	+20.2	USA
Hamelin	32.8	+20.4	West Germany
Kin	34.4	+20.4	Japan
Kok	28.1	+15.7	Sarawak
Libertad	29.4	+23.3	Venezuela
Lins	29.8	+15.9	Brazil
Lod	31.6	+21.2	Israel
Luck	36.9	+17.4	USA
Mut	35.7	+22.7	Turkey
Nune	38.6	+17.7	Mozambique
Nutak	30.3	+17.6	Canada
Oraibi	32.4	+17.4	USA
Ore	33.9	+16.9	Congo
Pylos	30.1	+16.9	Greece
Ribe	29.2	+16.6	Denmark
Shawnee	31.5	+22.7	USA
Soochow	28.9	+16.8	China
Sūf	38.2	+16.6	Jordan
Surt	30.6	+17.0	Libya
Taxco	40.0	+20.8	Mexico
Tile	28.6	+17.8	Somalia
Vaux	42.8	+18.1	France
Wahoo	33.7	+23.5	USA
Wabash	33.7	+21.5	USA
Warra	37.5	+20.8	Australia
Yala	36.5	+17.5	Thailand
Yar	39.1	+22.5	USSR
Yat	29.1	+18.3	Niger
Yoro	28.0	+23.0	Honduras
Yuty	34.1	+22.4	Paraguay
Zir	36.6	+18.7	Turkey
Zuni	29.6	+19.6	USA

6. Delete the name Hippalus Tholus 89°W +76° on Sheet MC 1.

7. Change the term for the crater Galileo to Galilaei.

Resolution V

OUTER SOLAR SYSTEM NOMENCLATURE

1. The names of new satellites should follow the traditions established by the existing names for satellites in a given system.

2. Within this guideline the discoverer of a new satellite should be free to choose the name for his discovery.

3. In the case of Jupiter, there are now many reasons for applying names to the satellites that presently only have numbers. Following the rule given in V 1 above, we propose the following names:-

the innermost satellite

J V Amalthea

the outer satellites

J VI	Himalia	J VIII	Pasiphae
J VII	Elara	J IX	Sinope
J X	Lysithea	J XI	Carme
J XIII	Leda	J XII	Ananke

The left hand column contains satellites with direct orbits, and names ending in "a". The right hand column contains satellites with retrograde orbits, and names ending in "e". The name "Leda" was proposed by the discoverer of J XIII, Dr. Charles Kowal.*

4. In anticipation of the discovery of surface features on the satellites of Jupiter and Saturn, we proposed to use the mythologies of various cultures as sources of names for such features. We can use epics from a given mythology to provide a natural association for names of various types of features in a given area or on a given satellite. We also propose to use words from Esperanto to name features on some of the smaller satellites.†

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* We acknowledge with gratitude our indebtedness to Dr. Jürgan Blunck for his essential assistance in the development of satellite names for Jupiter. We depart from Dr. Blunck's proposal in two respects: We are not concerned about duplication of names already assigned to asteroids. Such duplication already exists and has not led to any confusion. We omit the name "Thebe" from consideration, because it is too close to "Phoebe", already assigned to a satellite of Saturn.

The tradition of using only numbers for J V - J XII stems from Barnard's discovery of J V at a time when even J I - IV were formally only recognized by number. This tradition is now out of favor, and at least two informal name systems are in use in some places. We also face the possible embarrassment of naming features on an unnamed object. It therefore seems necessary to name these satellites. Dr. Kowal has expressed a preference for using only numbers - his choice of "Leda" was offered if we decided to name all the satellites. Since this was our decision, we have accepted his suggested name.

† We shall try to adhere to whatever general practice is established by other task groups in the naming of topographic features within the bank of names we establish from our sources - e.g., latin names for types of feature: Rupes, Vallis, etc.; person names for craters: Jason, Thor, Gilgamesh, etc. We must recognize, however, the possibility that entirely new types of topographic features may be found on the satellites of the outer planets.

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5. Because of the existing confusion in the designation of the ring system of Saturn, we propose the following scheme:

   (a) We adopt the traditional divisions known as the A,B and C rings.

   (b) For material inside the inner boundary of ring C, we propose the designation D.

   (c) For material outside the outer boundary of ring A, we propose the designation E.

   (d) If additional divisions are discovered within any of these segments, we propose the use of subscripts such as A_1, A_2, etc.

Action Following Second Meeting

Resolution approved by the WGPSN in October, 1975.

Resolved that the large craters on Mercury be named after great contributors to the humanities and the arts; including (but not limited to): authors of drama, prose and poetry; painters; sculptors; architects; composers; and musicians.

Third Meeting

Resolutions from the Third Meeting of the I.A.U. Working Group for Planetary System Nomenclature, Grenoble, France, August 30 and 31, 1976.

Resolution I

PUBLICATION OF PLANETARY SYSTEM NOMENCLATURE

We recommend that:-

1. All official actions on nomenclature, approved by the I.A.U. at a General Assembly, be printed in the Transactions of the I.A.U.

2. That there be produced, for wide distribution, a comprehensive publication including all planetary nomenclature resolutions and lists of names officially approved by the I.A.U. up to and including the XVI General Assembly; and that all future approved planetary nomenclature be published in supplementary volumes following each General Assembly.

Resolution II

LUNAR NOMENCLATURE

1. We recommend approval of the following list of 107 names of scientists and 13 Latin words as now assigned and printed on the 1:250,000 lunar map series and marked "provisional".

ABETTI (A.)	1846-1928 Italian astronomer	19.8 N, 27.7 E
ACOSTA (C.) (replaces Langrenus C)	c. 1525-c. 1594 Spanish; natural history, medicine	5.5 S, 60.0 E
AGRICOLA, MONTES (Georgius)	1494-1555 German earth scientist	LAC 38

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AL-BAKRI (A.A.) (replaces Tacquet A)	1010-1094 Spanish/Arabian geographer	14.5 N, 20.3 E
ALDROVANDI, DORSA (Ulisse)	1522-1605 Italian earth scientist	LAC 42
AL-MARRAKUSHI (replaces Langrenus D)	fl. 13th century Muslim astronomer, mathematician	10.2 S, 55.8 E
AL-TUSI	fl. 13th century Muslim astronomer, mathematician	7.0 N, 120.0 E
AMEGHINO (F.) (replaces Apollonius C)	c. 1854-1911 Italian anthropologist	3.4 N, 57.0 E
AMMONIUS (replaces Ptolemaeus A)	c. 517-526 Greek/Egyptian philosopher	8.5 S, 0.8 W
AMONTONS (Guillaume)	1663-1705 French physicist	5.2 S, 46.8 E
AMORIS, SINUS	Latin name meaning love	LAC 43
ANDRONOV (Aleksandr A.)	1901-1952 Russian physicist	22.7 S, 146.0 E
ANDRUSOV, DORSA (Nicolai I.)	1861-1924 Czechoslovakian palaeontologist	LAC 80
ANVILLE (J.B.) (replaces Taruntius G)	1697-1782 French cartographer	2.0 N, 49.5 E
ARDUINO, DORSUM (Giovanni)	1713-1795 Italian earth scientist	LAC 39
ARGAND, DORSA (Emile)	1879-1940 French earth scientist	LAC 39
ARMINSKI (Franciszek)	1789-1848 Polish astronomer	16.4 S, 154.1 E
ASADA (G.) (replaces Taruntius A)	1734-1799 Japanese astronomer	7.5 N, 49.9 E
ASPERITATIS, SINUS (replaces Torricelli R and surrounding mare)	Latin word meaning roughness	LAC 78
ATWOOD (G.) (replaces Langrenus K)	1745-1807 English mathematician, physicist	5.7 S, 57.5 E
AZARA, DORSUM (F. de)	1742-1811 Spanish earth scientist	LAC 42
BALANDIN (A.A.)	1898-1967 Russian chemist	19.0 S, 152.5 E
BANCROFT (W.D.) (replaces Archimedes A)	1867-1953 American chemist	28.0 N, 6.5 W
BARLOW, DORSA (W.)	1845-1936 English earth scientist	LAC 61
BEKETOV (N.N.) (replaces Jansen C)	1827-1911 Russian chemist	16.3 N, 29.2 E
BENEDICT (F.G.)	1870-1957 American chemist, physiologist	4.7 N, 141.7 E

BERGMAN (T.O.)	1735-1784 Swedish chemist, mineralogist, astronomer	7.4 N, 137.5 E
BILHARZ (T.) (replaces Langrenus F)	1825-1862 German anatomist, zoologist	5.5 S, 56.2 E
BINGHAM (H.)	1875-1956 American explorer	8.0 N, 115.0 E
BOBILLIER (E.) (replaces Bessel E)	1798-1840 French geometrist, mechanics	19.5 N, 15.5 E
BOETHIUS (replaces Dubiago U)	480?-524 Greek physicist	5.8 N, 72.3 E
BOMBELLI (R.) (replaces Apollonius T)	1526-1572 Italian algebraist	5.8 N, 56.0 E
BONITATIS, LACUS	Latin name meaning goodness	LAC 43
BOWDITCH (Nathaniel)	1773-1848 American navigator, astronomer, mathematician	25.0 S, 103.0 E
BREWSTER (D.) (replaces Römer L)	1781-1868 Scottish; optics	23.5 N, 34.7 E
BUCHER, DORSUM (W.H.)	1889-1965 Swiss earth scientist	LAC 39
BUCKLAND, DORSUM (W.)	1784-1856 English earth scientist	LAC 41,42
BURNET, DORSA (Thomas)	1635-1715 English earth scientist	LAC 38
CARTAN (E.J.) (replaces Apollonius D)	1869-1951 French mathematician	4.5 N, 59.3 E
CATO, DORSA ('The Censor')	234 B.C. - 149 B.C. Greek founder of geological engineering	LAC 61
CAYEUX, DORSUM (Lucien)	1864-1944 French sedimentary petrographer	LAC 62
CLOOS, DORSUM (Hans)	1885-1951 German earth scientist	LAC 64
CONCORDIAE, SINUS	Latin name meaning harmony	LAC 61
CONDON (Edward U.) (replaces Webb R)	1902-1974 American physicist	2.2 N, 60.3 E
VON COTTA, DORSUM (Carl B.)	1808-1879 German earth scientist	LAC 42
CRILE (G.) (replaces Proclus F)	1864-1943 American surgeon	14.5 N, 46.0 E
CTESIBIUS	ca. 100 B.C. Egyptian physicist	1.5 N, 118.5 E
CUSHMAN, DORSUM (J.A.)	1881-1949 American micropaleontologist	LAC 61
DANA, DORSA (James D.)	1813-1895 American earth scientist	LAC 64

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D'ARSONVAL (Jacques Aresne)	1851-1940 French physicist	10.0 S, 124.3 E
DOLORIS, LACUS	Latin word meaning anguish	LAC 41
EPPINGER (H.) (replaces Euclides D)	1879-1946 Czechoslovakian physician	9.5 S, 25.8 W
EWING, DORSA (W. Maurice)	1906-1974 American geophysicist	LAC 75
FABBRONI (Giovanni V.M.) (replaces Vitruvius E)	1752-1822 Italian chemist	18.6 N, 29.3 E
FAHRENHEIT (Gabriel Daniel) (replaces Picard X)	1686-1736 Dutch physicist	13.3 N, 61.6 E
FELICITATIS, LACUS	Latin word meaning happiness	LAC 41
FIDEI, SINUS	Latin word meaning trust	LAC 41
FINSCH (O.F.H.)	1839-1917 German zoologist	23.7 N, 20.7 E
FISCHER (Emil) " (Hans)	1852-1919 German chemist (Nobel, 1902) 1881-1945 German organic chemist(Nobel,1930)	8.2 N, 142.6 E
GAUDII, LACUS	Latin word meaning joy	LAC 42
GEIKIE, DORSA (Archibald)	1835-1924 Scottish geologist	LAC 80
GEISSLER (Heinrich) (replaces Gilbert D)	1814-1879 German physicist	2.3 S, 76.5 E
GLAUBER (Johann Rudolph)	1603/4-1668/70 German chemist	11.7 N, 142.8 E
GRABAU, DORSUM (Amadeus W.)	1870-1946 American earth scientist	LAC 40
GRAVE (Dmitriy A.) " (Ivan P.)	1863-1939 Russian mathematician 1874-1960 Russian; ballistics	17.0 S, 150.0 E
GUETTARD, DORSUM (Jean-Etienne)	1715-1786 French earth scientist	LAC 76
HARDEN (Sir Arthur)	1865-1940 English chemist (Nobel, 1929)	5.5 N, 143.7 E
HARKER, DORSA (Alfred)	1859-1939 English petrologist	LAC 62
HEIM, DORSUM (Albert)	1849-1937 Swiss earth scientist	LAC 40
HERON (also written Hero)	Ca. 100 B.C. Egyptian physicist	1.0 N, 119.6 E
HIEMALIS, LACUS (replaces Menelaus R)	Latin word meaning winter	LAC 60
HIGAZY, DORSUM (Riad)	1919-1967 Arab earth scientist	LAC 40

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HONORIS, SINUS	Latin word meaning honor	LAC 60
HUME (David)	1711-1776 Scottish historian and philosopher	4.5 S, 90.5 E
IBN BATTUTA (replaces Goclenius A)	c.1304-c.1368/9 Arabian geographer, traveller	7.0 S, 50.5 E
IBN FIRNAS	A.D. 274/887 Spansih; humanities, technology	7.5 N, 122.5 E
IBN-RUSHD (Averroës) (replaces Cyrillus B)	1126-1198 Muslim philosopher, physician	11.5 S, 21.5 E
KOSBERG (C.A.)	1903-1965 Soviet; aircraft construction	20.2 S, 149.5 E
KUIPER (Gerard P.) (replaces Bonpland E)	1905-1973 American astronomer	10.0 S, 22.5 W
KUNDT (August) (replaces Guericke C)	1839-1894 German physicist	11.5 S, 11.5 W
LANDER (Richard Lemon)	1804-1834 English explorer	15.3 S, 131.5 E
LEAKEY (Louis S.B.) (replaces Censorinus F)	1903-1972 British archaeologist	3.0 S, 37.5 E
LENITATIS, LACUS (replaces Manilius N)	Latin word meaning softness	LAC 60
LINDBERGH (Charles A.) (replaces Messier G)	1902-1974 American aviator	5.3 S, 53.0 E
LISTER, DORSA (Martin)	1638-1712 British stratigrapher	LAC 42
MACMILLAN (William Duncan)	1871-1948 American mathematician	24.2 N, 8.0 W
MOISSAN (Ferdinand F.H.)	1852-1907 (Nobel, 1906) French chemist	5.0 N, 137.4 E
MORO, MONS (A. Lazzaro)	1687-1740 Italian earth scientist	12.0 S, 19.6 W
NAONOBU (Ajima) (replaces Langrenus B)	c. 1732-1798 Japanese mathematician	4.5 S, 57.7 E
NICOL, DORSUM (William)	1768-1851 Scottish physicist	LAC 42
NIGGLI, DORSUM (Paul)	1888-1953 Swiss earth scientist	LAC 38
NOBILI (Leopoldo) (replaces Schubert Y)	1784-1835 Italian physicist	0.5 N, 76.0 E
NORMAN (Robert) (replaces Euclides B)	ca. 1590 English physicist, navigator	12.0 S, 30.5 W
ODII, LACUS	Latin word meaning hatred	LAC 41
OPPEL, DORSUM (Albert)	1831-1865 German palaeontologist	LAC 44,62
OWEN, DORSUM (George)	1552-1613 English earth scientist	LAC 42

PENCK, MONS (Albrecht)	1858-1945 German geographer	10.0 S, 21.5 E
PETIT (Alexis Therese) (replaces Apollonius W)	1791-1820 French physicist	2.5 N, 64.0 E
RANKINE (William John M.)	1820-1872 Scottish physicist, engineer	3.4 S, 71.2 E
RASPLETIN (Aleksandr A.)	1908-1967 Soviet radio engineer	22.5 S, 151.7 E
RICHARDS (Theodore W.)	1868-1928 (Nobel, 1914) American chemist	8.0 N, 140.0 E
RUBEY, DORSA (William W.)	1898-1974 American geologist	LAC 75
SCILLA, DORSUM (Agostino)	1639-1700 Earth scientist	LAC 38
SMIRNOV, DORSA (Sergei S.)	1895-1947 Russian earth scientist	LAC 42
SMITHSON (James) (replaces Taruntius N)	1765-1829 English chemist	2.5 N, 53.5 E
SODDY (Frederick)	1877-1956 (Nobel, 1921) British physicist	0.8 N, 121.5 E
SOLITUDINIS, LACUS	Latin word meaning loneliness	LAC 100
SOMERVILLE (Mary Fairfax) (replaces Langrenus J)	1780-1872 Scottish physicist, mathematician	8.0 S, 65.0 E
SORBY, DORSA (Henry C.)	1826-1908 English chemist	LAC 42
STILLE, DORSA (Hans)	1876-1966 German earth scientist	LAC 40
TERMIER, DORSUM (Pierre)	1859-1930 French geologist	LAC 62
TOLANSKY (Samuel) (replaces Parry A)	1907-1973 English physicist	9.8 S, 16.0 W
VAN BIESBROECK (G.A.) (replaces Krieger B)	1880-1974 American astronomer	28.8 N, 45.6 W
VIVIANI (Vincenzo)	1622-1703 Italian physicist, mathematician	6.0 N, 117.0 E
WHISTON, DORSA (William)	1666-1753 English earth scientist	LAC 38
WINTHROP (John) (replaces Letronne P)	1714-1779 American physicist and astronomer	10.8 S, 44.5 W
WROBLEWSKI (Sigmund von)	1845-1888 Polish physicist	24.0 S, 152.7 E
XENOPHON	434-355 B.C. Athenian historian	22.7 S, 121.9 E
ZÄHRINGER (Josef) (replaces Taruntius E)	1929-1970 German cosmochemist	5.7 N, 40.2 E
ZIRKEL, DORSUM (Ferdinand)	1838-1912 German earth scientist	LAC 40

2. We recommend approval of the following list of 195 names of scientists as a bank of names for future use on the moon. Nobel prize winners are starred.

AIKEN, Howard Hathaway	1900-1973	American mathematician
ALBERT, Abraham Adrian	1905-1972	American mathematician
ALBERTUS MAGNUS	c. 1200-1280	German natural scientist
*ALDER, Kurt	1902-1958	German chemist (Nobel, 1950)
ALDEROTTI, Taddeo	1223-c. 1295	Italian physician
ALDINI, Giovanni	1762-1834	Italian physicist
ANUCHIN, Dmitrii N.	1843-1923	Russian geographer, anthropologist
BACCELLI, Guido	1832-1916	Italian physician
BACHMANN, Augustus Q.	1652-1723	German botanist
BAER, Karl Ernst von	1792-1876	Estonian embryologist, biologist
BAILEY, Liberty Hyde, Jr.	1858-1954	American botanist
BAIRD, Spencer Fullerton	1823-1887	American zoologist
BALBIANI, Edouard G.	1823-1899	French biologist
BANKS, Joseph	1743-1820	English botanist
BANTI, Guido	1852-1925	Italian pathologist
*BÁRÁNY, Robert	1876-1936	Austrian physician (Nobel,1914)
*BARKLA, Charles G.	1877-1944	British physicist (Nobel, 1917)
BARTOLOTTI, Gian Giacomo	c. 1470-d. after 1530	Italian physician
BARTON, Benjamin S.	1766-1815	American botanist, zoologist
BASSI, Agostino M.	1773-1856	Italian natural scientist
BATES, Henry W.	1825-1892	English natural scientist
BECCARI, Nello	1883-1957	Italian anatomist
BELLINI, Lorenzo	1643-1704	Italian physiologist
BELON, Pierre	1517-1564	French zoologist, botanist
BENEDETTI, Alessandro	c. 1450-1512	Italian anatomist
BENEDICKS, Carl Axel Fredrik	1875-1958	Swedish metallographer
*BERGIUS, Friedrich	1884-1959	German chemist (Nobel, 1931)
BERKELEY, George	1685-1753	British scientific philosopher
BERNARD, Claude	1813-1878	French physiologist
BEZOUT, Étienne	1739-1783	French mathematician
*BLACKETT, Patrich Maynard S.	1897-1974	English physicist (Nobel, 1948)
BOAS, Franz	1858-1942	German-American anthropologist
BÖHLER, Lorenz	1885-1973	Austrian surgeon
BONNET, Charles	1720-1793	Swiss natural scientist, biologist

BORDET, Jules	1870-1961	Belgian bacteriologist, physiologist
*BORN, Max	1882-1970	German physicist (Nobel, 1954)
BOS, Willem Hendrik van den	1896-1974	Dutch astronomer
*BOSCH, Carl	1874-1940	German chemist (Nobel, 1931)
*BOTHE, Walther	1891-1957	German physicist (Nobel, 1954)
BOULE, Marcellin	1861-1942	French geologist
BOVERI, Theodor	1862-1915	German zoologist, biologist
BOWER, Frederick Orpen	1855-1948	English botanist
BRAHMAGUPTA	598-d. after 665	Indian astronomer
BRANDT, Georg	1694-1768	Swedish chemist, mineralogist
*BRAUN, Ferdinand	1850-1918	German physicist (Nobel, 1909)
BROCA, Pierre Paul	1824-1880	French physician, anthropologist
BRODE, Wallace R.	1900-1974	American chemist
BROOM, Robert	1866-1951	Scottish paleontologist
*BUCHNER, Eduard	1860-1917	German chemist (Nobel, 1907)
BUCKINGHAM, Edgar	1867-1940	American physicist
BUONANNI, Filippo	1638-1725	Italian natural scientist
CAILLETET, Louis Paul	1832-1913	French physicist
CANDOLLE, Augustin-Pyramus de	1778-1841	Swiss botanist
*CARREL, Alexis	1873-1944	French surgeon, physiologist (Nobel, 1912)
CASTILLON, Johann	1704-1791	Italian mathematician
*CHADWICK, James	1891-1974	British physicist (Nobel, 1935)
CHERRIE, George K.	1865-1948	American naturalist
CHEVREUL, Michel E.	1786-1889	French chemist
CLAPEYRON, Benoit-Pierre-Émile	1799-1864	French physicist
COCKERELL, Theodore D.A.	1866-1948	English zoologist
*CORI, Gerty Theresa R.	1896-1957	Czechoslovakian/American biochemist (Nobel, 1947)
CORRENS, Carl	1864-1933	German botanist
CUÉNOT, Lucien	1866-1951	French zoologist
*DALÉN, Nils Gustaf	1869-1937	Swedish engineer (Nobel, 1912)
DE BARY, Anton	1831-1888	German botanist
DE L'HOPITAL, Guilliaume F.A.	1661-1704	French mathematician
*DIELS, Otto Paul Hermann	1876-1954	German chemist (Nobel, 1950)
DIETRICH, Amalie Nelle	1821-1891	German botanist
*DOMAGK, Gerhard	1895-1964	German chemist, pathologist (Nobel, 1939)
DULONG, Pierre Louis	1785-1838	French physicist, chemist

EAST, Edward Murray	1879-1938	American biologist
EDDY, Nathan Browne	1890-1973	American pharmacologist
EKEBERG, Anders Gustaf	1767-1813	Swedish chemist
EMICH, Friedrich Peter	1860-1940	Austrian chemist
ENGLER, Adolf G.H.	1844-1930	German botanist
ERASISTRATUS	b.c. B.C. 304	Greek anatomist
*ERLANGER, Joseph	1874-1965	American physiologist (Nobel, 1944)
FAGON, Guy-Crescent	1638-1718	French botanist
FARLOW, William G.	1844-1919	American botanist
*FIBIGER, Johannes A.G.	1867-1928	Danish pathologist (Nobel,1926)
*FINSEN, Niels Ryberg	1860-1904	Danish physician (Nobel, 1903)
*FLOREY, Howard Walter	1898-1968	British pathologist (Nobel, 1945)
FLÜCKIGER, Otto	1881-1942	Swiss geographer
FLUDD, Robert	1574-1637	English chemist, physician
FORBES, James David	1809-1868	Scottish physicist
FÜCHSEL, Georg C.	1722-1773	German stratigrapher
GALTON, Francis	1822-1911	English anthropologist
*GASSER, Herbert Spencer	1888-1963	American physiologist (Nobel, 1944)
GEGENBAUR, Karl	1826-1903	German anatomist, zoologist
GIBBON, John Heysham, Jr.	1903-1973	American physician
GORE, John Ellard	1845-1910	Irish astronomer
GRASHCHENKOV, Nikolai I.	1901-1965	Soviet neurologist
GRAY, Asa	1810-1888	American botanist
GREW, Nehemiah	1641-1712	English physician, botanist
*GRIGNARD, Victor	1871-1935	French chemist (Nobel, 1912)
GROOTEN, Christian	c.1530-c.1603	German cartographer
*GUILLAUME, Charles Édouard	1861-1938	Swiss physicist (Nobel, 1920)
*HABER, Fritz	1868-1934	German/Swiss chemist (Nobel, 1918)
HAECKEL, Ernst H.	1834-1919	German zoologist, biologist
HALES, Stephen	1677-1761	English physiologist, botanist
HARRISON, Ross Granville	1870-1959	American biologist
*HAWORTH, Walter Norman	1883-1950	English chemist (Nobel, 1937)
*HENCH, Philip Showalter	1896-1965	American physician (Nobel,1950)
*HEVESY, George	1885-1966	Hungarian chemist (Nobel, 1943)
*HEYROVSKÝ, Jaroslav	1890-1967	Czechoslovakian chemist (Nobel, 1959)
*HINSHELWOOD, Cyril	1897-1967	English chemist (Nobel, 1956)

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HOFMEISTER, Whilhelm F.B.	1824-1877	German botanist
HOOKER, Joseph Dalton	1817-1911	English botanist
*HOUSSAY, Bernardo Alberto	1887-1971	Argentinian physiologist (Nobel, 1947)
HUTCHINSON, John	1884-1972	English botanist
IBN BAJJA	1106-1138	Spanish-Arab astronomer
IBN BUTLAN	c. 1000-1068	Arabian physician
*KARRER, Paul	1889-1971	Russian-Swiss chemist (Nobel, 1937)
*KENDALL, Edward Calvin	1886-1972	American biochemist (Nobel, 1950)
KERR, John	1824-1907	Scottish physicist
*KOCHER, Emil Theodor	1841-1917	Swiss surgeon (Nobel, 1909)
KOHLRAUSCH, Friedrich W.G.	1840-1910	German physicist, chemist
*KOSSEL, Albrecht	1853-1927	German chemist (Nobel, 1910)
*KUHN, Richard	1900-1967	Austrian chemist (Nobel, 1938)
*LAVERAN, Charles Louis Alphonse	1845-1922	French physician (Nobel, 1907)
LEFSCHETZ, Solomon	1884-1972	Russian-American mathematician
LEHRMAN, Daniel S.	1919-1972	American psychologist
*LENARD, Philip Edward Anton	1862-1947	German physicist (Nobel, 1905)
LEUCKART, Karl G.F.R.	1822-1898	German zoologist
*LIPPMAN, Gabriel	1845-1921	French physicist (Nobel, 1908)
LISSAJOUS, Jules Antoine	1822-1880	French physicist
MACLEOD, John J.R.	1876-1935	Scottish physiologist
MALPIGHI, Marcello	1628-1694	Italian biologist, physician
MALUS, Étienne Louis	1775-1812	French physicist
MATHIAS, Émile-Ovide-Joseph	1861-1942	French physicist
MAXIM, Hiram Percy	1869-1936	American inventor
*MEYERHOF, Otto	1884-1951	German physician (Nobel, 1922)
MILLIONSHCHIKOV, Mikhail D.	1913-1973	Soviet applied physicist
*MINOT, George R.	1885-1950	American physician (Nobel,1934)
*MORGAN, Thomas Hunt	1866-1945	American zoologist (Nobel,1933)
MURPHY, Robert Cushman	1887-1973	American zoologist
MUSSCHENBROEK, Petrus van	1692-1761	Dutch physicist
NÄGELI, Karl Wilhelm von	1817-1891	Swiss botanist
NICHOLS, Ernest Fox	1869-1924	American physicist
OSBORN, H. Fairfield	1857-1935	American paleontologist
PECORA, William Thomas	1913-1972	American geologist
PELETIER, Jacques	1517-1582	French mathematician
PEREGRINUS, Peter	fl. c. 1270	French engineer, inventor

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PREFFER, Wilhelm F.P.	1845-1920	German botanist, chemist
PLANTE, Gaston	1834-1889	French physicist
PLÜCKER, Julius	1801-1868	German physicist, mathematician
*POWELL, Cecil Frank	1903-1969	English physicist (Nobel, 1950)
*PREGL, Fritz	1869-1930	Austrian chemist (Nobel, 1923)
RABINOWITCH, Eugene	1901-1973	American biophysicist
*RICHARDSON, Owen Williams	1879-1959	English physicist (Nobel, 1928)
*RICHET, Charles Robert	1850-1935	French physiologist (Nobel, 1939)
ROTCH, A. Lawrence	1861-1912	American meteorologist
*ROUS, Peyton	1879-1970	American physician (Nobel,1966)
ROUX, Wilhelm	1850-1924	German zoologist
RUHMKORFF, Heinrich Daniel	1803-1877	German-French inventor
*SABATIER, Paul	1854-1941	French chemist (Nobel, 1912)
SAUVEUR, Joseph	1653-1716	French physicist, mathematician
SCHIMPER, Andreas F.W.	1856-1901	Swiss botanist
SCHWANN, Theodor	1810-1882	German anatomist
SEEBECK, Thomas Johann	1770-1831	German physicist
SIEMIENOWICZ, Kazimierz	fl. c. 1650	Polish artillery expert
SIKORSKY, Igor Ivanovich	1889-1972	Russian-American aeronautical engineer
*SPEMANN, Hans	1869-1941	German biologist, zoologist (Nobel, 1935)
*STANLEY, Wendell M.	1904-1971	American biochemist (Nobel, 1946)
*STAUDINGER, Hermann	1881-1965	German chemist (Nobel, 1953)
STEARNS, Carl Leo	1892-1972	American astronomer
*STERN, Otto	1888-1969	German physicist (Nobel, 1943)
STRASBURGER, Eduard Adolf	1844-1912	German botanist
*SVEDBERG, Theodor	1884-1971	Swedish chemist (Nobel, 1926)
*TAMM, Igor	1895-1971	Soviet physicist (Nobel, 1958)
*THEILER, Max	1889-1972	South African bacteriologist (Nobel, 1951)
*TISELIUS, Arne	1902-1971	Swedish biochemist (Nobel,1948)
TORREY, John	1796-1873	American botanist, chemist
TSVET, Mikhail S.	1872-1919	Russian botanist
ULRICH, Edward O.	1857-1944	American paleontologist
VAN BENEDEN, Edouard	1846-1910	Belgian cytologist
VINOGRADSKI, Sergei N.	1856-1953	Russian/French microbiologist
VIRCHOW, Rudolph L.K.	1821-1902	German pathologist
*VIRTANEN, Artturi I.	1895-1973	Finnish biochemist (Nobel,1945)

*VON BAEYER, Adolf	1835-1917	German chemist (Nobel, 1905)
*VON BEHRING, Emil A.	1854-1917	German bacteriologist (Nobel, 1901)
*VON BÉKÉSY, Georg	1899-1972	Hungarian physicist (Nobel, 1961)
VON GOEBEL, Karl I.E.	1855-1932	German botanist
VON HALLER, Albrecht	1708-1777	Swiss physician
VON SACHS, Julius	1832-1897	German botanist
*WAGNER-JAUREGG, Julius	1857-1940	Austrian physician (Nobel,1927)
*WALLACH, Otto	1847-1931	German chemist (Nobel, 1910)
*WARBURG, Otto H.	1883-1970	German biochemist (Nobel, 1931)
WEISMANN, August	1834-1914	German biologist
*WIELAND, Heinrich Otto	1877-1957	German chemist (Nobel, 1927)
*WIEN, Wilhelm	1864-1928	German physicist (Nobel, 1911)
*WILLSTÄTTER, Richard	1872-1942	German chemist (Nobel, 1915)
WINCHELL, Newton Horace	1839-1914	American geologist
*WINDAUS, Adolf O.R.	1876-1959	German chemist (Nobel, 1928)
ZWICKY, Fritz	1898-1974	Swiss astrophysicist

3. We recommend approval of the following list of 20 names of scientists as a bank of names for future use on the moon, and the second biography of one name to be added to the records of a name already approved and assigned.

BIALOBRZESKI (C.)	1878-1953	Polish physicist
BRASIL (V.)	1865-1950	Brazilian biologist
BRONK (D.W.)	1897-1975	American physiologist
DE MORAES (A.)	1916-1970	Brazilian astronomer
HARKHEBI	circa 300 B.C.	Egyptian astronomer
HOPMANN (J.)	1890-1975	Austrian astronomer
KAMIENSKI (M.)	1879-1973	Polish astronomer
KEPINSKI (F.)	1885-1966	Polish astronomer
KOWALCZYK (J.)	1833-1911	Polish astronomer
LINDSAY (E.M.)	1907-1974	Irish astronomer
OLIVIER (C.P.)	1884-1975	American astronomer
PIENKOWSKI (S.)	1883-1953	Polish physicist
PIKEL'NER (S.B.)	-1975	Russian astronomer
POCZOBUTT (O.M.)	1728-1808	Polish astronomer
PRAZMOWSKI (A.)	1821-1885	Polish astronomer
PRISCILLA BOK (F.)	1896-1975	American astronomer
VERTREGT (M.)	1897-1973	Dutch chemist & space scientist
VINOGRADOV (A.P.)	1895-1975	Russian geo-chemist & cosmo-chemist

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WILDT (R.)	1905-1976	American astronomer of German birth
ZONN (W.)	1905-1975	Polish astronomer

MINKOWSKI (R.L.B.)	1895-1976	American astronomer (second biography to be added to name already approved)

4. We recommend approval of the following 12 names, assigned to lunar elevations:-

MONS	EULER	LAC	Region	39
"	GRUITHUISEN DELTA	"	"	23
"	GRUITHUISEN GAMMA	"	"	23
"	HANSTEEN	"	"	74
"	HERODOTUS	"	"	38
"	MORO	"	"	76
"	PENCK	"	"	78
"	VITRUVIUS	"	"	43
MONTES	AGRICOLA	"	"	38
"	ARCHIMEDES	"	"	41
"	SECCHI	"	"	61
MONS	MARALDI	"	"	43

(correction of Mons Maraldi Gamma)

5. We recommend approval of the following list of 6 lacus names on the moon:-

LACUS	EXCELLENTIAE	35 S, 045 W
"	LUXURIAE	19 N, 175 E
"	OBLIVIONIS	21 S, 169 W
"	SPEI*	43 N, 064 E
"	TEMPORIS	46 N, 055 E
"	TIMORIS	39 S, 028 W

*Previously Lacus Struve

6. We recommend approval for the name of one valley and of the names of 12 crater chains, named after the nearest named crater to facilitate their location and recognition:-

VALLIS	BOHR	LAC	Region	55
CATENA	ABULFEDA	"	"	96
"	ARTAMONOV	"	"	46
"	DAVY	"	"	77
"	DZIEWULSKI	"	"	46
"	GREGORY	"	"	65
"	HUMBOLDT	"	"	99
"	KRAFFT	"	"	55

CATENA	KURCHATOV	LAC	Region	31
"	LEUSCHNER	"	"	71
"	MENDELEEV	"	"	66
"	SUMNER	"	"	30
"	SYLVESTER	"	"	1

7. We recommend that the area bounded approximately by Montes Carpatus (N), Crater Flammarian (E), Mare Cognitum (S) and Crater Kepler (W) be named MARE INSULARUM.

8. We recommend that the term DORSUM, plural DORSA, include curvilinear elevations in the lunar maria (i.e. wrinkle ridges) as well as normal ridges; and that all DORSA continue to be named after geoscientists, as is now the practice (see Resolution II(1) above).

9. We recommend that RIMAE, singular RIMA, long depressions on the moon (straight, arcuate or sinuous) if within a crater, be named after that crater; or otherwise, be named after the nearest named formation, preferable a crater.

Resolution III

MERCURY NOMENCLATURE

1. We recommend the approval of 136 crater names as assigned on Mercury Quadrangles H-6,7,8,11,15 of the 1:5,000,000 Mercury map series.

NAME, with biographical information	Quadrangle	Lat.(°)	Long.(°)	Diam.(km)
ABU NUWAS, (762-810)	H-6	17.5	21	115
AFRICANUS HORTON, (1835-1883)	H-11	-50.5	42	120
AL-JĀHIZ, (d. 869)	H-6	1.5	22	95
AMRU AL-QAYS, (Pre-Islamic)	H-8	13	176	50
ANDAL, (18th century)	H-11	-47	35.5	90
ASVAGOSHA, (1st century)	H-6	11	21	80
BACH, J.S., (1685-1750)	H-15	-69	103	225
BALAGTAS, F., (1788-1862)	H-6	-22	14	100
BALZAC, H. de,(1799-1850)	H-8	11	145	65
BEETHOVEN, L. van, (1770-1827)	H-7	-20	124	625
BELLO, A., (1781-1865)	H-7	-18.5	120.5	150
BERNINI, G.L.,(1598-1680)	H-15	-79.5	136	145
BOCCACCIO, G., (1313-1375)	H-15	-80.5	30	135
BOETHIUS, (480-524)	H-7	- 0.5	74	130
BRAMANTE, (1444-1514)	H-11	-46	62	130
BRUNELLESCHI, F., (1377-1446)	H-6	- 8.5	22.5	140
BYRON, G.G., (1788-1824)	H-6	- 8	33	100
CALLICRATES, (5th century BC)	H-11	-65	32	65
CAMÕES, L.V. de, (1524-1580)	H-15	-70.5	70	70
CARDUCCI, G., (1835-1907)	H-11	-36	90	75

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NAME, with biographical information	Quadrangle	Lat.(°)	Long.(°)	Diam.(km)
CERVANTES, M. de, (1547-1616)	H-15	-75	122	200
CHAIKOVSKIJ, P.I., (1840-1893)	H-6	8	50.5	160
CHAO MENG-FU, (d.1322)	H-15	-87.5	132	150
CHEKHOV, A., (1860-1904)	H-11	-35.5	61.5	180
CHIANG K'UI, (12th century)	H-7	14.5	103	105
CHOPIN, F.F., (1810-1849)	H-15	-64.5	124	100
CHU TA, (c.1624-c.1705)	H-7	2.5	106	100
COLERIDGE, S.T., (1772-1834)	H-11	-54.5	66.5	110
COPLEY, J.S., (1738-1815)	H-11	-37.5	85.5	30
DARÍO, R., (1867-1916)	H-11	-26	10	160
DICKENS, C., (1812-1870)	H-15	-73	153	72
DONNE, J., (1572-1631)	H-6	3	14	90
DÜRER, A., (1471-1528)	H-7	22	119.5	190
DVORAK, A., (1841-1904)	H-6	- 9.5	12.5	80
EITOKU, (1543-1590)	H-8	-21.5	157.5	105
EQUIANO, A., (c. 1750-1797)	H-11	-39	31	80
FUTABATEI, S., (1864-1909)	H-7	-15.5	83.5	55
GHIBERTI, L. (1378-1455)	H-11	-48	80	100
GIOTTO, (1266/67?-1337)	H-6	12.5	56	150
GOYA y L.F.J. de, (1746-1828)	H-8	- 6.5	152.5	135
GUIDO D'AREZZO, (c. 995-1050)	H-11	-38	19	50
HANDEL, G.F., (1685-1759)	H-6	4	34	150
HARUNOBU, (1725-1770)	H-7	15.5	141	100
HAYDN, J., (1732-1809)	H-11	-26.5	71.5	230
HESIOD, (c. 800 BC)	H-11	-58	35.5	90
HIROSHIGE, A., (1797-1858)	H-6	-13	27	140
HITOMARO, (7th-8th century)	H-6	-16	16	105
HOLBERG, L., (1684-1754)	H-15	-63.5	61	66
HOMER, (8th or 9th century BC)	H-6	- 1	36.5	320
HORACE, (65-8 BC)	H-15	-68.5	52	48
IBSEN, H.J., (1828-1906)	H-6	-24	36	160
ICTINUS, (2nd half 5th century BC)	H-15	-79	165	110
IMHOTEP, (c. 2680 BC)	H-6	-17.5	37.5	160
JUDAH HA-LEVI, (c. 1075-1141)	H-7	11.5	108	85
KĀLIDĀSĀ, (5th century?)	H-8	-17.5	180	110
KEATS, J., (1795-1821)	H-15	-69.5	154	110
KENKŌ, Y., (14th century)	H-6	-21	16.5	90
KHANSA, (Pre-Islamic)	H-11	-58.5	52	100

NAME, with biographical information	Quadrangle	Lat.(°)	Long.(°)	Diam.(km)
KUROSAWA, K., (18th century)	H-11	-52	23	180
LEOPARDI, G., (1798-1837)	H-15	-73	180	69
LERMONTOV, M. Yu., (1814-1841)	H-6	15.5	48.5	160
LI CH'ING-CHAO, (1081-after 1141)	H-15	-77	73	60
LI PO, (701-762)	H-6	17.5	35	120
LU HSUN, (1881-1936)	H-6	0.5	23.5	95
LYSIPPUS, (4th century BC)	H-7	1.5	133	150
MA CHIH-YUAN, (fl. 1251)	H-11	-59	77	170
MACHAUT, G. de, (c. 1300-1377)	H-7	- 1.5	83	105
MAHLER, G., (1860-1911)	H-6	-19	19	100
MARK TWAIN, (1835-1910)	H-7	-10.5	138.5	140
MARTÍ, J.J., (1853-1895)	H-15	-75.5	164	63
MATISSE, H., (1869-1954)	H-7	-23.5	90	210
MELVILLE, H., (1819-1891)	H-6	22	9.5	135
MENA, J. de, (1411-1456)	H-7	0.5	125	20
MENDES PINTO, F., (c. 1510-1583)	H-11	-61	19	170
MICKIEWICZ, A., (1798-1855)	H-7	23.5	102.5	115
MILTON, J., (1608-1674)	H-8	-25.5	175	175
MISTRAL, G., (1889-1957)	H-6	5	54	100
MOFOLO, T., (1873-1948)	H-11	-37	29	90
MOLIÈRE, (1622-1673)	H-6	16	17.5	140
MOZART, W.A., (1756-1791)	H-8	8	190.5	225
MURASAKI S., (11th century)	H-6	-12	31	125
NAMPEYO, (c. 1860-1942)	H-11	-39.5	50.5	40
NEUMANN, B., (1687-1753)	H-11	-36.5	35	100
OVID, (43 BC-17 AD)	H-15	-69.5	23	40
PETRARCH, (1304-1374)	H-11	-30	26.5	160
PHIDIAS, (active from about 475-430 BC, or later)	H-8	9	150	155
PHILOXENUS, (3rd century BC)	H-7	- 8	112	95
PIGALLE, J.B., (1714-1785)	H-11	-37	10.5	130
PO CHÜ-I, (772-846)	H-8	- 6.5	165.5	60
PO YA, (8th-5th century BC)	H-11	-45.5	21	90
POLYGNOTUS, (c. 500-400 BC)	H-6	0	68.5	130
PROUST, M., (1871-1922)	H-6	20	47	140
PUCCINI, G., (1858-1924)	H-15	-64.5	46	110
PUSHKIN, A.S., (1799-1837)	H-15	-64.5	23	200
RABELAIS, F., (c. 1483-1553)	H-11	-59.5	62.5	130

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NAME, with biographical information	Quadrangle	Lat.(°)	Long.(°)	Diam.(km)
RAJNIS, Ya., (1865-1925)	H-7	5	96.5	85
RAMEAU, J.P., (1683-1764)	H-11	-54	38	50
RAPHAEL, (1483-1520)	H-7	-19.5	76.5	350
RENOIR, P.A., (1841-1910)	H-6	-18	52	220
REPIN, I.E., (1844-1930)	H-6	-19	63	95
RILKE, R.M., (1875-1926)	H-11	-45.5	13.5	70
RODIN, A., (1840-1917)	H-6	22	18.5	270
RUBLEV, A., (c. 1380-1430)	H-8	-14.5	157.5	125
R̄UDAKĪ, (10th century)	H-6	- 3.5	51.5	120
SADĪ, (c. 1213-1292),	H-15	-77.5	56	60
SCHOENBERG, A., (1874-1951)	H-7	-15.5	136	30
SCHUBERT, F., (1797-1828)	H-11	-42	54.5	160
SCOPAS, (1st half 4th century BC)	H-15	-81	173	95
SEL, S., (11th century)	H-11	-63.5	88.5	130
SHEVCHENKO, T.G., (1814-1861)	H-11	-53	47	130
SINAN, I.A.Al'M., (1489-1588)	H-6	16	30	140
SNORRI, S., (1179-1241)	H-7	- 8.5	83.5	20
SOPHOCLES, (c. 496-406 BC)	H-8	- 6.5	143.5	145
SŌTATSU, (d. 1643)	H-11	-48	19.5	130
SPITTELER, C.F.G., (1845-1924)	H-15	-68	62	66
SULLIVAN, L., (1856-1934)	H-7	-16	87	135
TANSEN,	H-7	4.5	72	25
THĀKUR, R., (1861-1941)	H-6	- 2.5	64	115
THEOPHANES, (14th century)	H-7	- 4	143	50
TINTORETTO, (1518-1594)	H-11	-47.5	24	60
TITIAN, (c. 1487/1490-1576)	H-6	- 3	42.5	115
TOLSTOJ, L.N., (1828-1910)	H-8	-15.0	165	400
TS'AI WEN-CHI, (2nd century AD)	H-6	23.5	22.5	120
TS'AO CHAN, (c. 1715-1763)	H-7	-13	142	110
TSURAYUKI, K.N., (10th century)	H-11	-62	22.5	80
TYAGARAJA, (18th century)	H-8	4	149	100
UNKEI, (13th century)	H-11	-31	62.5	110
VĀLMIKI, (1st century BC)	H-7	-23.5	141.5	220
VAN GOGH, V.W., (1853-1890)	H-15	-76	135	95
VIVALDI, A., (1678-1741)	H-7	14.5	86	210
WAGNER, R., (1813-1883)	H-15	-67.5	114	135
WANG MENG, (1308-1385)	H-7	9.5	104	170
WERGELAND, H.A., (1808-1845)	H-11	-37	56.5	35

NAME, with biographical information	Quadrangle	Lat.(°)	Long.(°)	Diam.(km)
YEATS, W.B., (1865-1939)	H-6	9.5	35	90
YUN SǑN-DO, (1587-1671)	H-15	-72.5	109	61
ZEAMI, (15th century)	H-8	- 2.5	148	125

2. We recommend the approval of the following 6 rupes names as assigned on Mercury:-

	Lat.	Long.
ADVENTURE	-64°	063°
GJÖA	-65	163
POURQUOI-PAS	-58	156
RESOLUTION	-62	052
ZARYA	-42	022
ZEEHAEN	+50	158

3. We recommend the following 9 sheet names for the 1:5,000,000 map series of Mercury:-

Sheet No.	Name	Sheet No.	Name
1	BOREALIS	8	TOLSTOJ
2	VICTORIA	11	DISCOVERY
3	SHAKESPEARE	12	MICHAELANGELO
6	KUIPER	15	BACH
7	BEETHOVEN		

Resolution IV

MARS NOMENCLATURE

1. We recommend approval of the following list of 6 names as assigned to large craters (diameter greater than 100 km) on Mars.

	Lat.	Long.
BYRD	-26°	235°
GUSEV	-14°	184°
LASSWITZ	-09°	222°
LUZIN	-26°	328°5
SCHÖNER	+20°	309°5
WIEN	-11°	220°5

2. We recommend approval of the list of 271 names of small cities and villages, as assigned to small craters (diameter less than 10 km) on Mars.

NEREIDUM MONTES REGION

Name	Country of origin	Coordinates	
Albi	France	34°7	-41°9
Azul	Argentina	42.3	-42.5
Baltisk	USSR	54.5	-42.6
Bozkir	Turkey	31.9	-44.5
Camiri	Bolivia	41.9	-45.1
Choctaw	USA	37.0	-41.5
Cypress	USA	47.0	-47.6
Delta	USA	39.0	-46.3
Dese	Ethiopia	30.3	-45.8
Dessau	GDR	53.0	-43.1
Eger	Hungary	51.8	-48.7
Flora	USA	51.2	-45.0
Gah	Indonesia	32.3	-45.1
Gali	USSR	36.9	-44.1
Gandu	Brazil	47.0	-45.8
Ham	France	32.2	-45.0
Hilo	USA	35.5	-44.8
Jezža	USSR	37.7	-48.8
Kartabo	Guyana	52.3	-41.2
Kakori	India	29.6	-41.9
Kampot	Cambodia	45.4	-42.1
Karpinsk	USSR	31.8	-46.0
Kem'	USSR	32.7	-45.3
Kifrī	Iraq	54.1	-46.0
Kribi	Cameroon	43.4	-43.4
Kushva	USSR	35.2	-44.3
Lemgo	FRG	34.5	-42.9
Luga	USSR	47.2	-44.6
Mafra	Brazil	53.0	-44.4
Maidstone	UK (England)	54.1	-41.9
Nazca	Peru	38.2	-44.0
Ochakov	USSR	31.6	-42.5
Podor	Senegal	43.0	-44.6
Porvoo	Finland	40.6	-43.7
Rengo	Chile	43.5	-43.9
Salaga	Ghana	51.0	-47.6
Sarno	Italy	54.0	-44.7
Satka	USSR	36.7	-43.0
Sauk	USA	32.25	-45.0
Sokol	USSR	40.5	-42.8
Tabou	Ivory Coast	34.8	-45.5
Talsi	USSR	49.1	-41.9
Tara	Ireland	52.7	-44.4
Tarakan	Borneo	30.1	-41.6
Taza	Morocco	45.1	-44.0
Tombe	Sudan	44.4	-42.8
Tōno	Japan	52.2	-45.2
Torsö	Sweden	51.0	-44.7
Turbi	Kenya	51.2	-40.9
Valga	USSR	36.3	-44.6
Vätö	Sweden	53.2	-43.9
Wau	New Guinea	42.4	-45.2
Yungay	Peru	44.6	-44.3

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ERYTHRAEUM REGION

Name	Country of Origin	Coordinates	
Alga	USSR	26°5	-24°6
Aspen	USA	22.9	-21.6
Balta	USSR	26.4	-24.1
Bar	USSR	19.3	-25.6
Bend	USA	27.5	-22.6
Bentong	Malaysia	18.9	-22.6
Bigbee	USA	34.6	-25.0
Bison	USA	29.0	-26.6
Blitta	Togo	20.8	-26.3
Bogra	Bangladesh	28.6	-24.4
Boru	USSR	27.7	-24.6
Buta	Zaire	32.2	-23.5
Calbe	GDR	28.7	-25.5
Campos	Brazil	27.6	-22.0
Cartago	Costa Rica	17.8	-23.6
Chapais	Canada	20.4	-22.6
Chekalin	USSR	26.6	-24.5
Cheb	Czechoslovakia	19.3	-24.5
Circle	USA	25.4	-22.4
Cluny	France	27.1	-24.1
Cobalt	USA	26.8	-26.1
Crewe	UK (England)	19.4	-25.2
Deba	Nigeria	17.1	-24.3
Dingo	Australia	17.3	-24.0
Dison	Belgium	16.3	-25.4
Eads	USA	29.8	-28.9
Echt	UK (Scotland)	28.0	-22.2
Edam	Netherlands	19.9	-26.6
Ely	USA	27.1	-23.9
Falun	Sweden	24.4	-24.2
Fastov	USSR	20.2	-25.4
Flat	USA	19.4	-25.8
Gagra	USSR	21.9	-20.9
Galu	Zaire	21.5	-22.3
Gardo	Somalia	24.6	-27.0
Gatico	Chile	20.9	-21.2
Globe	USA	27.1	-24.0
Glazov	USSR	26.4	-20.8
Goba	Ethiopia	20.9	-23.5
Golden	USA	33.3	-22.2
Gori	USSR	28.6	-23.2
Grójec	Poland	30.6	-21.6
Guir	Mali	20.4	-21.8
Ḥaraḍ	Saudi Arabia	27.8	-27.8
Honda	Colombia	16.2	-22.7
Inta	USSR	24.9	-24.6
Irbit	USSR	24.7	-24.6
Jal	USA	28.6	-26.6
Kagul	USSR	18.9	-24.0
Kaj	USSR	29.2	-27.4
Kanab	USA	18.8	-27.6
Kansk	USSR	17.1	-20.8
Kantang	Thailand	17.3	-24.8
Karshi	USSR	19.2	-23.6

ERYTHRAEUM REGION (Cont'd.)

Name	Country of Origin	Coordinates	
Kashira	USSR	18°1	-27°5
Kasimov	USSR	22.8	-25.0
Kimry	USSR	16.2	-20.5
Kirs	USSR	19.3	-26.7
Kirsanov	USSR	25.0	-22.4
Kita	Mali	17.0	-23.1
Kuba	USSR	19.5	-25.6
Lamas	Peru	20.5	-27.4
Lar	Iran	28.8	-26.1
Lebu	Chile	19.4	-20.6
Livny	USSR	28.9	-27.5
Longa	Angola	25.7	-20.9
Loto	Zaire	22.3	-22.2
Lorica	Colombia	28.1	-19.9
Manzī	Burma	27.3	-22.3
Murgoo	Australia	22.3	-24.0
Mila	Algeria	20.6	-27.5
Nan	Thailand	19.8	-27.1
Nardo	Italy	32.7	-27.8
Navan	Ireland	23.2	-26.2
Nepa	USSR	19.5	-25.3
Nitro	USA	23.8	-21.5
Noma	Namibia	24.0	-25.7
Ōmura	Japan	25.0	-25.7
Ostrov	USSR	27.9	-26.9
Plum	USA	18.9	-26.4
Pabo	Uganda	22.9	-27.3
Polotsk	USSR	26.1	-20.1
Rana	Norway	21.6	-26.0
Revda	USSR	28.3	-24.6
Romny	USSR	18.0	-25.7
Ruby	USA	16.9	-25.6
Sandila	India	30.2	-25.9
Sangar	USSR	24.1	-27.9
Say	Niger	29.5	-28.5
Seminole	USA	18.9	-24.5
Shambe	Sudan	30.5	-20.7
Sibu	Malaysia	19.6	-23.3
Sigli	Indonesia	30.6	-20.5
Singa	Sudan	17.2	-22.8
Thule	Denmark (Greenland)	25.5	-23.6
Tak	Thailand	28.45	-26.4
Timaru	New Zealand	22.2	-25.6
Tiwi	Oman	24.6	-27.9
Tura	USSR	21.8	-27.0
Voo	Kenya	19.8	-27.3
Yegros	Paraguay	23.5	-22.5

CHRYSE REGION

Bor	USSR	33°8	+18°5
Chur	USSR	29.3	+17.1
Banff	Canada	31.6	+17.8
Kaup	New Guinea	36.6	+22.5

CHRYSE REGION (Cont'd.)

Name	Country of Origin	Coordinates	
Kipini	Kenya	32°0	+24°8
Naukan	USSR	30.1	+21.3
Trud	USSR	30.7	+17.7

CYDONIA REGION

Name	Country of Origin	Coordinates	
Chom	Tibet	2°2	+38°7
Cruz	Venezuela	1.7	+38.6
Dein	New Guinea	2.4	+38.5
Gaan	Somalia	3.8	+38.9
Gwash	Pakistan	3.1	+39.3
Lutsk	USSR	3.2	+38.9
Wer	India	6.2	+45.9

CAPRI REGION

Name	Country of Origin	Coordinates	
Azusa	USA	40°55	- 5°5
Bahn	Liberia	43.45	- 3.5
Balboa	Panama Canal Zone	34.05	- 3.8
Batoka	Rhodesia	36.8	- 7.6
Berseba	South W. Africa	37.7	- 4.4
Bamba	Zaire	41.7	- 3.5
Butte	USA	39.05	- 5.1
Byske	Sweden	31.1	- 4.95
Camiling	Philippines	38.1	- 0.8
Chimbote	Peru	39.8	- 1.5
Chinju	Republic of Korea	42.3	- 4.6
Conches	France	34.3	- 4.2
Creel	Mexico	38.95	- 6.1
Daet	Phillippines	41.9	- 7.4
Dia-cau	Vietnam	42.8	- 0.3
Glide	USA	43.3	- 8.2
Groves	USA	44.75	- 4.15
Huancayo	Peru	39.85	- 3.7
Innsbruck	Austria	30.1	- 6.5
Kaid	Iraq	44.8	- 4.55
Kholm	Afganistan	42.1	- 7.3
Kong	Ivory Coast	38.7	- 5.45
Locana	Italy	38.3	- 3.45
Lachute	Canada	39.9	- 4.3
Manti	USA	37.7	- 3.65
Mega	Ethiopia	37.05	- 1.5
Misk	Turkey	35.45	- 0.95
Manah	USSR	33.75	- 4.75
Oglala	USA	38.35	- 3.1
Paks	Hungary	42.15	- 7.75
Pinglo	China	36.9	- 3.0
Quorn	Australia	33.75	- 5.55
Rakke	USSR	43.5	- 4.75
Rincon	Netherlands Antilles	43.1	- 8.1
Rypin	Poland	41.05	- 1.25
Sfax	Tunisia	43.5	- 7.75
Sitka	USA	39.35	- 4.3
Spry	USA	38.6	- 3.75

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CAPRI REGION (Cont'd.)

Name	Country of Origin	Coordinates	
Stobs	UK (Scotland)	38°4	- 5°0
Tarata	Bolivia	41.35	- 3.8
Timbuktu	Mali	37.6	- 5.6
Tuskegee	USA	36.2	- 2.9
Vaales	Spain	33.1	- 3.95
Wicklow	Iceland	40.7	- 2.0
Windfall	Canada	43.5	- 2.1
Wink	USA	41.5	- 6.6
Žulanka	USSR	42.3	- 2.3

TRITONIS LACUS REGION

Bacht	USSR	257°45	+18°9
Basin	USA	253.15	+18.1
Bluff	New Zealand	250.1	+23.7
Brush	USA	248.8	+21.9
Cost	USA	256.1	+15.25
Dank	Oman	253.15	+22.2
Gastre	Argentina	247.6	+24.8
Goff	Somalia	255.2	+23.5
Gulch	Ethiopia	251.15	+16.1
Kaw	French Guiana	255.85	+16.7
Linpu	China	247.0	+18.3
Marbach	Switzerland	249.2	+17.9
Moss	Norway	250.7	+19.4
Naic	Philippines	252.75	+24.7
Phon	Thailand	257.3	+15.8
Porth	UK (Wales)	255.85	+21.45
Troika	USSR	255.0	+17.1
Viana	Brazil	255.25	+19.45

WESTERN CHRYSE REGION

Banh	Upper Volta	55°3	+19°9
Belz	USSR	43.2	+21.8
Bise	Okinawa	56.7	+20.6
Blois	France	55.6	+24.1
Bole	Ghana	53.7	+25.5
Broach	India	56.6	+24.1
Cairns	Australia	47.3	+24.0
Changsŏng (Lun-Gu)	Republic of Korea	57.1	+24.0
Chauk	Burma	55.6	+23.9
Chinook	Canada	55.2	+23.0
Chive	Bolivia	55.7	+22.2
Clogh	N. Ireland	47.6	+20.8
Dromore (Lun-Cr)	N. Ireland	49.3	+20.2
Guaymas (Lun-Aw)	Mexico	44.9	+26.0
Jijiga	Ethiopia	53.6	+25.7
Lexington	USA	48.5	+22.2
Naar	Egypt	42.1	+23.2
Nema (Lun-Ds)	USSR	52.0	+21.2
Nif	Yap	56.1	+20.3
Ottumwa (Lun-Fe)	USA	55.5	+25.2
Peixe	Brazil	47.5	+20.6

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WESTERN CHRYSE REGION (Cont'd.)

Name	Country of Origin	Coordinates	
Poona (Lun-Du)	India	24°3	+52°0
Puńsk	Poland	41.2	+20.7
Quick	Canada	49.1	+18.4
Rauch	Argentina	57.8	+21.8
Rong	Tibet	45.3	+22.8
Santa Fe (Lun-Br)	USA	47.8	+19.4
Sögel (Lun-Fs)	FRG	54.9	+21.9
Spur	USA	52.0	+22.5
Sucre	Colombia	54.3	+24.2
Tarsus	Turkey	40.2	+23.4
Troy	USA	52.3	+23.7
Valverde (Lun-Fr)	Dominican Republic	55.7	+20.6
Vol'sk	USSR	51.1	+23.5
Weer	Austria	51.5	+20.2
Yorktown	USA	48.5	+23.3
Waspam	Nicaragua	56.5	+20.9
Wassamu (Lin-Ew)	Japan	53.0	+26.1

3. We recommend approval of the following 10 names as assigned to channels on Mars:-

	Latitude	Longitude
ARDA VALLES	-20° to -22°	031° to 033°
BAHRAM VALLIS	western chryse	
CLOTA VALLIS	-25° to -26°5	20°5
DRINUS VALLES	-20°5 to -22°5	021°5 to 023°
MAMERS VALLES	+32° to +47°	338° to 348°
MAUMAE VALLIS	western chryse	
OLTIS VALLES	-22°5 to -25°	021° to 022°
RUBICON VALLES	+45°	116°
TAGUS VALLES	-07°	245°
VEDRA VALLES	western chryse	

4. We recommend approval of the following 7 names, as assigned to topographic features on Mars:-

AUREUM CHAOS	MC 19
IANI CHAOS	MC 19
AMENTHES FOSSAE	MC 14
SACRA FOSSA	MC 10
AEOLIS MENSAE	MC 23
NEPENTHES MENSAE	MC 14
XANTHE DORSA	western chryse

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5. We recommend approval of the following 2 Latin terms for use on Mars:-

SCOPULUS (Scopuli)	lobate or highly irregular scarps
SULCUS (Sulci)	a complex area of subparallel furrows and ridges

6. We recommend approval of the following 8 names, as assigned to topographic features on Mars:-

	Latitude	Longitude
*FRIGORIS SCOPULUS	+80°	020° to 305°
*HYPERBOREUS SCOPULUS	+80° to +85°	060° to 160°
*NILOKERAS SCOPULUS	+32° to +40°	040° to 052°
*HYPERNOTIUS SCOPULUS	-76° to -80°	230° to 315°
CYANE SULCI	+23° to +28°	126° to 130°
GIGAS SULCI	+08° to +14°	126° to 135°
LUCAS SULCI	+25° to +40°	130° to 148°
SULCI GORDI	+16° to +20°	125° to 127°

*Corrected from RUPES to SCOPULUS

7. We recommend that the name SILOE MENSAE (lat. +30° to +49°, long. 010° to 020°) be changed to CYDONIA MENSAE.

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In compliance with resolution I (1) of the third meeting of the WGPSN in Grenoble the following Table gives the names of the Apollo landing sites as approved by the IAU at the XVth General Assembly in Sydney.

Table

ASTRONAUT - NAMED LUNAR FEATURES IN THE APOLLO EXPLORATION SITES*

Apollo 11 Landing Site

West: Sharp-rimmed, rayed crater, about 180 m in diameter and 30 m deep. The crater occurs on the western edge of the Apollo 11 landing ellipse, hence the name "West". The LM landed approximately 400 m to the west of said crater.

Apollo 12 Landing Site

A. Crater Cluster names

1. Crescent: Descriptive name of a row of seven craters arranged in the form of an arch west of the landing site.

2. Snowman: An arrangement of five craters around the large crater in which Surveyor 3 landed. The geometry resembles the fabled and familiar "snowman" figure.

B. Crater names

1. Middle Crescent: (Sampling site) Crater in the middle of the aforementioned Crescent. Its rim was the farthest stop from the LM on the first EVA.

2. Head: (Sampling site) Crater that forms the head of the aforementioned Snowman pattern.

3. Bench: (Sampling site) Crater that forms the right arm to the Snowman arrangement; it displays a prominent bench which is indicative of excavation of bedrock beneath the regolith.

4. Sharp-Apollo: (Sampling site) Sharp-rimmed and bright-rayed crater west of Bench; it is located on the extreme southwestern end of the sampling traverse on the second EVA.

5. Halo: Small haloed crater on the south rim of the crater in which Surveyor 3 landed.

6. Surveyor: (Sampling Site) The site of the Surveyor 3 landing.

7. Block: Last sampling site, small crater within Surveyor crater.

*The designation "-Apollo" has been added to a few names which duplicate those of previously named lunar craters. The designation indicated that the crater is in one of the Apollo landing sites.

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Apollo 14 Landing Site

1. Cone: A 350 m crater situated on the western edge of one of the high ridges of the Fra Mauro Formation. The physical location and ejecta of the crater give it a cone-shaped appearance. The south rim of the crater was the farthest stop of the second EVA surface sampling traverse.

2. Triplet: Three craters in a row, "North", "Center", and "South", that served as the first major landmark for landing the craft. The Apollo 14 LM landed west of North Triplet. Samples were also collected from North Triplet.

3. Doublet: Two superposed craters west of the landing point that served as the second major landmark for landing the craft. The Laser Ranging Retro Reflector was deployed on the southeast rim of Doublet crater.

4. Flank:A 30 m crater on the southwestern flank of Cone crater.

5. Old Nameless: Crater with broken rim.

6. Weird:A 40 m unusual cluster of probably two or possibly three craters forming a unique or "weird" shape. A large rock sampled east of this crater has already been named weird rock !

Apollo 15 Landing Site

The following 14 names were carefully selected from an original list of 81 names given to features and craters in the Apollo 15 landing site area.

A. Feature names

1. Apennine Front: The explored foothills of Hadley Delta which is part of the Apennine Mountain range on the eastern rim of Mare Imbrium.

2. North Complex: Complex of hills, craters, scarps and apparent flow fronts to the north of the landing site.

3. South Cluster: A cluster of secondary craters located to the south of the landing site. The western part of the cluster was explored on the second EVA.

4. Plain: A flat mare region on which the LM landed east of Rima Hadley.

5. Terrace: Slight projection of a basalt-mare unit out into Rima Hadley. The farthest sampling point to the west on EVA 3 was in its vicinity.

B. Crater names

1. Bridge: Crater within Rima Hadley whose rim appears to form a bridge across the rille. Crater was used as a landmark.

2. Dune: Crater named for a dune-shaped structure on the southeast rim. Dune crater was the sampling site of Station number 4.

3. Earthlight: A crater named after an Arthur C. Clarke novel by the same name. The crater was described in detail during the second EVA.

4. Elbow: Crater at a part of Rima Hadley resembling a bent elbow. The crater was the site of sampling station number 1.

5. Index: A prominent crater near the landing site that served as the major landmark for orbital tracking and for LM descent.

6. Last:This crater was supposed to be visited on the last traverse; it became the last crater to be approached during descent. The LM landed in its vicinity.

7. Rhysling: A crater named for Rhysling, the blind poet of "The Green Hills of Earth", a science fiction story by Robert Heinlein. Sampling station number 3 is 125 m west-southwest of the crater.

8. Spur: Crater located on a small spur of the Apennine Front. The southernmost part of the second EVA traverse was in the vicinity of this crater.

9. St.George: In Jules Verne's "From the Earth to the Moon", the moon-bound crew members celebrated a successful launch by drinking a type of wine by the name of St. George. This 2.5 km in diameter crater on the Apennine Front was the source of soil sample.

Apollo 16 Landing Site

The following 19 names were chosen from several lists of crew-given names of features and craters in the landing site area.

A. Feature names

1. Smoky Mountains: Mountainous mass north of the landing site.

2. Stone Mountain: Mountainous mass south of the landing site.

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B. Crater names

1. Baby Ray: A small rayed crater atop bright rays of a larger crater.

2. Cinco: A group of five craters ("cinco" is "five" in Spanish) on the foot-hill of Stone Mountain in the vicinity of the southern-most portion of the second EVA traverse.

3. Spot: Two overlapping craters that served as a landing landmark. The LM landed about 100 m north of the craters.

4. End: End for being the last planned stop on the last EVA.

5. Flag: Sampling site of Station number 2 on the rim of Plum.

6. Gator: Large crater named for alligator.

7. Halfway: Crater centrally located between sampling sites 1 and 2.

8. Kiva: Crater named after the Pueblo Indian architectural structure which is usually round.

9. North Ray: One kilometer diameter bright-rayed crater north of the landing point. The ejecta and rim of the crater were sampling sites number 11 and 13.

10. Palmetto: A crater, one kilometer in diameter, named after the palm tree of the same name.

11. Plum: Large crater with Flag on the rim.

12. Ravine: A large irregular depression on the base of Smoky Mountains, part of which appears much like a ravine, a small narrow, steep-sided valley.

13. South Ray: One kilometer diameter bright-rayed crater south-southwest of the landing point. Ray materials from this crater were collected at several locations in the landing site area.

14. Spook: A crater that is one-half kilometer downrange from the landing spot. The crater's location represented a hazard and worried the crew during the preparation and training for the mission. Sampling station number 2 was on the rime of this crater.

15. Stubby: A crater, one kilometer in diameter, with a stocky and thick pro-trusion from Stone Mountain. Sampling station 6 is on the north rim of this crater.

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16. Trap: An old, subdued and partly hidden depression that hindered planning a southwesterly traverse to sample and study Baby Ray.

17. Wreck: Sampling station number 8; a relatively old crater whose original features appear disordered and ruined by later events. The crater is located between Stubby and Trap. All three craters were used as landmarks for LM landing.

Apollo 17 Landing Site

The following 29 names were selected from the list of 67 crew-given names in the Apollo 17 landing site area.

A. Feature names

1. Bear Mountain: A cluster of hills that forms the shape of a bear.

2. Family Mountain: Named for the families of the crew members, their associates and families in general.

3. Light Mantle: Fingered mantling deposit, believed to be a landslide.

4. North Massif: Massif is a French term for a large mountain mass, this one north of the landing site.

5. Scarp: A scarp, with mare ridge-like segments, located west of the landing site.

6. Sculptured Hills: Domical hills, surrounding the landing site area, which appear sculptured.

7. South Massif: Mountain mass south of the landing site area.

8. Tortilla Flat: Flat region near the Light Mantle.

9. Wessex Cleft: A cleft in the eastern border of North Massif. Wessex was an ancient Anglican kingdom.

10. Taurus-Littrow Valley: General landing site area

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B. Crater names

1. Brontë: Crater near which the first LRV stop was made; Charlotte Brontë was a 19th century English novelist.

2. Bowen-Apollo: Crater near the farthest eastern limits of the third EVA traverse.

3. Camelot: Crater named for the legendary King Arthur of the Round table, Station number 5 was on the rim of this crater.

4. Cochise: Crater named for the American Indian Apache chief. The crater was studied and described on the third EVA.

5. Emory: Large crater used as a major landmark. William H. Emory was a member of the Topographical Engineers who explored the American West.

6. Falcon: Small crater on Family Hill used for landmark tracking from orbit prior to lunar landing. It is also believed to be one of few cinder cones in the Apollo 17 site (previously, F. Crater).

7. Hess-Apollo: Large crater near Mackin-Apollo, named after the geologist H. Hess.

8. Horatio: Crater southwest of Camelot.

9. Lara: Girl's name; sampling site of station number 3.

10. Mackin-Apollo: Large crater used as a landmark, named after J. Hoover Mackin, an American geomorphologist.

11. Nansen-Apollo: Sampling site of station number 21

12. Powell: One of the large craters in the landing site area named for John Wesley Powell, an explorer of the American West.

13. Shakespeare: Large crater northeast of the landing site named after the English poet and playwright.

14. Sherlock: A crater that was used as a tracking landmark from orbit, also the last (12th) LRV sampling stop was north of the crater. It is named after Sherlock Holmes, the hero of Sir Arthur Conan Doyle's novels.

15. Shorty: A dark-rimmed crater with relatively short, dark rays; it is named after a character in Richard Brautigan's contemporary novel "Trout Fishing in America."

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16. Steno-Apollo: Sampling site of the first station named after the geologist Steno.

17. Trident: A triplet crater cluster shaped like the three pronged spear carried by Neptune to Poseidon, classical mythology's god of the sea.

18. Van Serg: Sampling station number 9 was on the rim of a small crater. It was named after the pseudonym that Prof. Hugh McKinstry, a 20th century mining geologist used in writing educational satire.

19. Victory: A large V-shaped depression.