

COMMISSION No. 40

RADIO ASTRONOMY (RADIOASTRONOMIE)

Report of Meetings, 3, 4, 5, 8, 9, 10 August, 1988

PRESIDENT: J.E. Baldwin

VICE-PRESIDENT: P.G. Mezger

Business Meetings

SECRETARY: T.L. Wilson

I NEW OFFICERS

Peter Mezger (FRG) was elected President and M. Morimoto (Japan) Vice-President for the period 1988-1991. Continuing members of the Organising Committee are J.E. Baldwin (UK), A. Baudry (France), R.S. Booth (Sweden), D.L. Jauncey (Australia), N. Kaifu (Japan), V.K. Kapahi (India), L. Matveyenko (USSR), G.D. Nicolson (South Africa), E.R. Seaquist (Canada). The following were elected as new members of the SOC: D.C. Backer (USA), R. Fanti (Italy), R. Guesten (FRG), J.M. Moran (USA), J.M. van der Hulst (Netherlands), Q.F. Yin (China).

II NEW MEMBERS

75 new members were admitted by the Commission bringing the total membership to over 750. The Commission continued its policy of not restricting further growth in its numbers. The advantages of a very large Commission with common interests in technique applied to a wide range of astronomical interests were thought to outweigh the difficulties of communication with the members. The full programme of Commission meetings together with its involvement in many Joint Discussions and Joint Commission Meetings supported this view.

III IUCAF

John Findlay, the retiring Chairman of IUCAF, presented a wide-ranging report of IUCAF activities. This explanatory review, which covers the reasons for the formation of IUCAF, its mandate, its work in recent years in coordinating efforts to protect frequency bands used for radioastronomy from man-made interference and its prospects for the future, is reprinted at the end of this report on Commission 40 activities. The Commission thanked John Findlay for the difficult and long-sustained work he had undertaken on their behalf.

Brian Robinson, the new Chairman of IUCAF, reported that the

increase in membership of IUCAF, sought by the previous Chairman, had been approved by the IAU. The IAU representation is increased from two to four; G. Swarup (India), V.L. Pankonin (USA), B.A. Doubinski (USSR) and N. Kaifu (Japan) were unanimously approved as members. Both IAU and URSI have agreed to increased funding for IUCAF. Thanks were given to the retiring member R. Schilizzi (Netherlands) and also to the retiring Secretary, A.R. Thompson (USA), who gave a report of CCIR activities in the period 1986-90. This raised many issues concerning present and potential future radio interference problems which were later addressed by the Working Group on the Protection of Spectral Lines (see section IV below) and were the subject of the IAU Resolutions discussed in section V. It was felt that it would be most valuable if a short list of CCIR reports could be distributed to Commission 40 members by its next President.

IV REPORT OF WORKING GROUPS

(a) Nomenclature

Burke (Chairman) reminded the Commission that this WG had presented its final report at the previous General Assembly. However, this occasion provided an opportunity to calm fears expressed by commission members that the use of J2000 coordinates would involve changing the names of well known objects. This was emphatically not the case. The Commission were cheered by this, thanked the Chairman and the WG and agreed to its dissolution.

(b) Protection of molecular line frequencies

Robinson (Chairman), Baudry, Cohen, Hjalmarson, Kahlmann, Kaufmann, Morimoto, Pankonin, Radhakrishnan, Slysh, Spoelstra, Tiuri, Turner, Webster, Wilson.

The work of the Group continues to expand due both to the continual reassessment of the importance of molecular lines in the existing lists and new candidates and to the growing number of actual and potential sources of radio interference. Discussions covered revision of the lists of important molecular lines, interference from GLONASS at 1612 MHz, frequency allocations at 1612 MHz for the radio-determination satellite service (RDSS), the Land Mobile Satellite allocation at 1660 - 1660.5 MHz, spread-spectrum interference from satellites and long term strategy for protection of passive radioastronomy bands at future WARC meetings. These topics formed the basis for Resolutions 5 and 6 listed in section V.

The revised lists of radio frequency lines of the greatest importance to astronomy are published with Resolution 7 elsewhere in these Transactions.

In view of the growing need for the attendance by radioastronomers at meetings concerned with frequency allocations and radio interference, the support of all Observatory Directors was requested by the Commission for supplying travel funds to appropriate meetings in their Region. Many of those present agreed in principle to contribute to a common fund or to support

members of their own staff for this purpose.

(c) VLBI

Johnston (Chairman), Ananthakrishnan, Backer, Biraud, Booth, Legg, Cohen, Grueff, Manchester, Kaufmann, Kellermann, Kus, Matveyenko, Morimoto, Nicolson, Pauliny-Toth, Schilizzi, Wilkinson, Yeh.

The meetings of the Working Group provide a focus for exchange of information on the present status of VLBI observatories throughout the world and reports on Playback Systems. The important issue of the availability of recording systems in the USA and Europe was also discussed.

V RESOLUTIONS

The problem of radio interference in radioastronomical observations, in particular due to transmissions from satellite systems, both actual and planned for the future, was a matter requiring the urgent attention of the Commission. The Working Group on the Protection of Molecular Line Frequencies under its Chairman Brian Robinson was instrumental in drafting Resolutions on these topics which had the unanimous support of the Commission. They were accepted as Resolutions of the Executive Committee and are printed elsewhere in these Transactions as Resolutions 5: Cooperation to save Hydroxyl Bands, 6: Sharing Hydroxyl Band with Land Mobile Satellite Services and 7: Revision of Frequency Bands for Astrophysically Significant Lines. The concerns of Commission 40 amongst others are also expressed in Resolution 2: Adverse Environmental Impacts on Astronomy.

VI SYMPOSIA

Commission 40 has taken part in planning several Symposia and colloquia during the three years since the last General Assembly (Symposia 124, 129, 134, 136; Colloquia 101, 112).

Symposia in various states of planning which involve the Commission included the following topics (contact person in brackets): Recombination lines (Kardashev), Paired and interacting galaxies (Sulentic), Extragalactic molecular clouds: dynamics and evolution of galaxies (Combes), Radioastronomical seeing (Wang), Magellanic Clouds and interaction with the Milky Way (Haynes), Magnetic fields in galaxies (Wielebinski), Magnetospheric structure and the emission mechanisms of pulsars (Rankin), Reference systems (J.A. Hughes), Structure of Molecular Clouds (Falgarone), Radio interferometry (Cornwell).

VII RADIO CATALOGUES

The attention of members was drawn by E.C. Campbell (Canada) to a list of all radio surveys from 1955 to the present which is to be published soon in Astronomy and Astrophysics Supplement.

Scientific Sessions

I. COMMISSION MEETINGS

Instrumentation, August 3, 1988 Chairman: R.S. Booth

Recent developments at Westerbork	E. Raimond
The upgrade of the Dominion Radio Astrophysical Observatory synthesis telescope	L.A. Higgs
The proposed Canadian multi-element synthesis telescope	L.A. Higgs
Recent developments at Jodrell Bank and the extension of MERLIN	P. Thomasson
The Very Long Baseline Array	J.D. Romney
The NRAO 12 m Telescope	D.T. Emerson
Improvements of the Nobeyama 45 m telescope	N. Kaifu
The Swedish-ESO Submillimetre Telescope; some results	R.S. Booth
The Nobeyama Millimetre-wave Array	M. Ishiguro
The NRAO millimetre array project	R.L. Brown
The Australia Telescope	R.D. Ekers

Solar System and Galactic Research, August 4, 1988 Chairman: N. Kaifu

Solar radio research at Clark Lake Radio Observatory	M.R. Kundu
HCN and OH observations of recent comets	D. Bockelée-Morvan
A model of core emission from pulsars	J. Rankin
A new flaring radio source in Cygnus	L.A. Higgs
OH/IR stars at the Galactic Centre	A. Winnberg
Mm-wave recombination lines	M. Gordon
Observations of NH ₃ emission with the Nobeyama mm-wave array	S. Okumura-Kawabe
Evolution of the local galactic magnetic field	S.J. Goldstein
New continuum surveys with the 100-m Telescope	R. Wielebinski
All sky survey at 34.5 MHz	K.S. Dwarakanath
Extreme scattering events	R. Feidler
Evolution of the morphology of supernova remnants with pulsars	D. Bhattacharja
Various HII regions in Cep A	V. Hughes
The case of the optical identification of the 6.1 msec pulsar P1953+29	V. Boriakoff

Extragalactic Research, August 4, 1988 Chairman:

Observations of the Coma cluster at 327 MHz	L. Feretti
The end of the jet in 3C 33 north	L. Rudnick
Development of high-frequency radio outbursts in AGN	E. Valtaoja
Polarisation asymmetry in double sources	R.G. Conway

Update on fluctuations in the cosmic microwave background	R.D. Davies
VLA observations of a new sample of Molonglo quasars: aspect dependence of the optical continuum	V.K. Kapahi
Moderately compact steep-spectrum sources	C. Akuja
Magnetic fields in external galaxies	R. Wielebinski
Recent results from Westerbork	C. O'Dea
OJ287 as a precessing eclipsing binary supermassive black hole system	M. Valtonen
OH Megamasers in galaxies - new results from Nancay	L. Gougenheim
Extragalactic supernovae as radio sources	K. Weiler
An unusually aligned radio source	K. Menon
Recent observations of gravitational lenses	D. Walsh

High Angular Resolution for Radio Astronomy in Space, August 10, 1988
 (with Commission 44) Chairmen: B.F. Burke, Y. Kondo

TDRSS experiment	R. Linfield
RADIOASTRON	N. Kardashev
VSOP	N. Kaifu
QUASAT status	R. Schilizzi
Orbital studies	R. Schilizzi
Prospects for low frequency space VLBI	K. Weiler
Two theorists' views	Paczynski, A. Ferrari
Speculations for the future	R.S. Booth, N. Kardashev

II JOINT COMMISSION MEETINGS

For Milliarcsec or Better Accuracy (4,7,8,19,24,31,40)	August 3
High Angular Resolution Imaging from the ground (9,40)	August 5
Molecules in External Galaxies (28,34,40)	August 5

Reports of these meetings are published in "Highlights of Astronomy" Vol 8

III JOINT DISCUSSIONS

SN1987A in the LMC	August 4
Atomic and Molecular Data for Astrochemistry	August 8
Disks and Jets on Various Scales in the Universe	August 9

IUCAF Report to the International Astronomical Union

by John W. Findlay

1. Introduction

Since I shall formally resign as Chairman of the Commission at the time of the forthcoming 20th General Assembly of the IAU it seems appropriate that the IUCAF Report to the IAU should be made to serve as a review of the work of IUCAF from its inception and also to give a

short look into the future. In this form it may be of interest to all the bodies which the Commission has tried to serve, so copies will be sent to ICSU, URSI and COSPAR.

2. The formation of IUCAF

The need to have bands of radio frequencies available for scientists to use at various parts of the spectrum was discussed first by URSI at the IXth General Assembly in Zurich in 1950. It was the fairly new science of radio astronomy which made the matter urgent, and between 1950 and 1957 the subject was studied by URSI, the IAU and, as soon as it was formed, by COSPAR. When the XIIth General Assembly of URSI convened at Boulder in 1957 with Lloyd V. Berkner as President, Sub-Commission Ve of the radio astronomy Commission V was formed to prepare for the forthcoming International Telecommunications Union (ITU) World Administrative Radio Conference (WARC) to be held in late 1959.

The tasks for this sub-Commission (of which the author became chairman in the early summer of 1958) were to establish the scientific requirements for the protection of bands of radio frequencies throughout the spectrum and then to take action to get these requirements presented to the WARC and, if possible, to get them approved. International agreement was reached on the scientific requirements for radio astronomy and this was formalized in a CCIR Recommendation No. 314 approved by the CCIR Plenary Meeting held in Los Angeles in April 1959. By this time the IAU had held a General Assembly in Moscow and in August 1958 had passed a resolution supporting the work of Commission Ve and calling for bands to be cleared not only for hydrogen-line observations, but also for a series of bands at octave intervals throughout the radio spectrum. COSPAR came into being in 1958 to carry on the rocket and satellite work started in the International Geophysical Year, and so also had an obvious interest in getting space science and space operations included in the 1959 WARC.

A WARC is a major meeting called by the ITU to regulate the use of the radio frequency spectrum. A WARC is essentially a treaty-making occasion and so its pattern of work is formal. Only member countries may make submissions to the WARC and these are usually worked out well in advance and given some limited diplomatic exposure before the WARC starts. Thus the second task given to Ve required that at least one administration would enter the needs of the scientists, and, if possible, several administrations would support them. As it turned out it was Netherlands which made the vital submission; this was largely due to the leadership of Professor Jan Oort. Since it was clear that the IAU and COSPAR were also concerned with the work of the WARC, a joint representation was arranged, with at least one person acting for all as an observer at the Conference. This co-operation can be regarded as the unofficial start of IUCAF.

The official formation of IUCAF was largely due to Lloyd Berkner. It was obvious when the work of Ve was reported at the XIIIth General Assembly of URSI at London in 1960 that the task of working to get

frequencies allocated for radio astronomy and space science should be done by an Inter-Union body. Berkner arranged a series of meetings in London which led directly to the formation of IUCAF as an ICSU Inter-Union Commission with URSI as parent Union and IAU and COSPAR as the other founding bodies.

During its first years IUCAF was composed of twelve members, four being appointed by each of the founding bodies. The Director of the CCIR and the Chairman of the International Frequency Registration Board (IFRB) act as advisers to IUCAF and there is a secretary. After some years the appointed membership was reduced to six.

3. The mandate of IUCAF

At its formation IUCAF was charged with the following tasks:

- (a) To study and coordinate the requirements for radio frequency allocations for radio astronomy and space science, and to make these requirements known to the national and international bodies responsible for frequency allocations;
- (b) To take action aimed at insuring that harmful interference is not caused to radio astronomy or space science, operating within the allocated bands, by other radio services.

The ITU usually holds a full WARC every twenty years but the growth of activities in space made it necessary to hold a WARC specially devoted to space frequencies in 1963. Radio astronomers were fortunate in having their service also included. IUCAF was deeply involved in this WARC, and the outcome was a much improved allocation table. The next full WARC, held in 1979, was again an opportunity to improve and extend the frequency protection for the IUCAF sciences. One important change made by this WARC was the inclusion of radio astronomy and space research together in a number of "passive" bands where no radio frequency power may be emitted at all by any service.

It will be clear from what has been written so far that the task in (a) above becomes most important when a WARC, either full scale or specialised, is planned for the near future. IUCAF attempts to keep up-to-date with the changes or growth of the scientific requirements of radio astronomy and space science by close contact with the relevant Commissions of URSI, IAU and COSPAR. This proves to be easier for radio astronomy than for space science, chiefly because of differences in the ways in which experimental work is planned. For example, a set of radio astronomical observations of the lines emitted by molecules in a particular region of sky determines at once the frequencies to be used. If the molecular lines are not judged to be important, they will not have got any form of "protection" and the observer will have to do his best to find a place and time suitable for his observations. But the lines may have been judged as important (and IUCAF, the IAU and the CCIR make and up-date such judgements) and then they are likely to have some degree of protection. And if the

science appears to justify an attempt to change the degree of protection, the proposal can be made to the ITU for such a change. In some space science there can also be a clear picture of the frequencies which are scientifically most important. Observations made from a satellite of the earth's atmosphere are an example. So also are some earth observation experiments, and studies of the ionosphere where frequencies in exact harmonic relation are needed. But quite a lot of space science does not call for exact frequency requirements although it may well need specific bandwidths to be available. In order to be informed on as wide a base as possible of the requirements of space science, IUCAF has become associated with the work of the Space Frequency Co-ordinating Group (SFCG), in addition to keeping in touch with the work of the CCIR Study Group 2 and the relevant COSPAR Commissions.

The SFCG consists of representatives from several space agencies and meets usually once a year. It is intended to provide a forum for multi-lateral discussion and coordination of spectrum and orbit matters of mutual interest concerning a number of space radio communication services. The group is particularly interested in getting an early understanding of future plans for space systems and in making suggestions with regard to current and future frequency needs. Members of the group also have an interest in radio astronomy and radar astronomy when these are relevant to spacecraft missions. For some years two members of IUCAF have been attending SFCG meetings as observers, and the informal interchanges have proved very useful. Despite the slightly informality, Dr. F. Horner of IUCAF acted as SFCG chairman at their meeting in Paris at the end of 1987.

4. IUCAF in recent years

(a) World Administrative Radio Conferences

The most recent full-scale WARC was held in 1979 and has already been referred to in paragraph 3 above. Two more specialised WARC's have taken place since that time, one on the use of the geostationary orbit met first in 1985 (ORB-85) and will convene for a second session at the end of August 1988. A WARC on the mobile services took place in Geneva in September 1987. This showed the pressure to introduce various services using satellite systems. The suggested frequencies lie close to the OH line frequencies. There was one serious outcome from this WARC as far as radioastronomy is concerned, and that was the re-allocation of the 1660 to 1660.5 MHz band to the Land Mobile Satellite Service, thus making it an equal partner in that band with radioastronomy. This situation is very unsatisfactory and will need action in the near future. The CCIR Study Group 8 has formed an International Working Party to study mobile satellite systems and it may be possible that this group will also consider the problems of sharing with radioastronomy.

It seems likely that the ITU will hold a WARC in the next few years to review the usage of the band of frequencies from one to three GHz. This band includes the hydrogen and hydroxyl lines and thus is

of paramount importance to radioastronomy. If such a WARC is to take place it will require preparation by IUCAF and radioastronomers world-wide.

(b) The "passive" frequency bands

Since about 1983 IUCAF has tried to act more energetically to look at the problems of harmful interference being radiated into the "passive" bands. These are the bands which at the 1979 WARC became allocated to passive services, such as Radioastronomy and Space Research (Passive). There have been cases of space-borne systems being planned or implemented in the 1600-1700 MHz part of the spectrum which appeared to be threatening. One such system, the launch of two spacecraft to Venus and then on to rendezvous with comet Halley used a spacecraft frequency of 1667.8 MHz which fell within a passive radio astronomy and space research band. There were good practical reasons for the choice of this frequency and the power levels radiated were low. The mission was very successful; IUCAF helped to inform radioastronomers of the transmission schedules of the spacecraft, and no interference was reported. (No problems were anticipated in space science since the power levels at earth were very low.)

The concerns that space-borne transmissions would impinge on the passive bands was expressed in resolutions passed within the past four years by URSI, and IAU and COSPAR. These asked administrations planning experiments requiring radio transmissions from space to use IUCAF to help protect sensitive passive radio observations.

This agreement on the need for further action by IUCAF on this difficult subject is certainly welcome; but the format for that action is far from clear. IUCAF has encouraged the international watch for potential or actual cases of improper usage of the protected bands. At present there are cases of damaging interference from satellites in the 1610-1614 MHz band, which is protected for radio observations of the OH line. Such cases can be studied and the characteristics of the interference can be made known to scientists in countries around the world. IUCAF documents on such interference go as a matter of course to the IFRB as an adviser to IUCAF. The relationship between IUCAF and the SFCG described in paragraph 3 also opens a channel by which planners of activities in space can be kept alert to the need to protect the protected bands. In fact, the SFCG at this meeting in Tokyo in April 1986 adopted a Resolution very similar to the statements from URSI, the IAU and COSPAR.

(c) Meetings of European Radio astronomers

Meetings of radio astronomers from most European observatories have been held in the spring of 1987 and again in 1988. These were organised by H.C. Kahlmann and T.A. Th. Spoelstra of the Netherlands Foundation for Radioastronomy. The purpose of the meetings was to recognise the real and growing threat to radio astronomy from interference generated by other spectrum users and then to identify means by which this threat could be countered. The objectives of these meetings were clearly parallel to those of IUCAF and so members of the Commission attended each meeting. At the first meeting the

following recommendation was agreed:

An informal and representative international group of radio astronomers, meeting in Paris on March 31st and April 1st 1987

CONSIDERING

1. the increasing threat to the survival of radio astronomy from transmissions of active services in some frequency bands, especially when air-borne or space stations are used by these services,
2. the general lack of awareness among astronomers that the radio windows to the universe are in danger of being at least partially closed by man-made interference,
3. that IUCAF exists for conveying to the ITU and to national communication authorities information on the frequency requirements of radio astronomers and space scientists
4. that nevertheless, it is necessary for firm proposals to the ITU be made through one or more national administrations

RECOMMENDS THAT IUCAF

1. continue efforts, both directly and through its parent unions, to raise the level of interest on matters of frequency allocation among astronomers in Europe and elsewhere,
2. request IAU to inform the managements of all radio astronomy observatories of the need to improve contacts with the users of active radio services in their countries, with the object of increasing general awareness of the damaging effects which those services could have on the radio astronomy service,
3. ensure that national scientific academies are made aware of the increasing threats to the survival of radio astronomy in many frequency bands and are requested to use their influence in obtaining satisfactory solutions to the problems of interference to observations.

(d) IUCAF and other meetings

IUCAF met together during the URSI Assembly in Tel Aviv in August 1987. Since the IAU Assembly in New Delhi the Commission has had representatives at the following meetings:

- (a) The 6th meeting of the SFCG, Tokyo, April 21-25 1986.
- (b) The XXVIth meeting of COSPAR, Toulouse, June 30 - July 11 1986.
- (c) The meetings of European Radio astronomers, Paris, April 31 - May

1st 1987 and Bonn, February 23 - 24th 1988.

(d) The 7th meeting of the SFCG, Paris November 16th - 20th 1987.

Throughout the period F. Horner has been the chairman of CCIR Study Group 2 and has thus been present at meetings of that group and also at the Joint Working Party for the ITU Orbit Conference 1988.

5. IUCAF in the next few years

It will be clear that the main tasks facing IUCAF in the coming years will be to maintain, and if possible to improve, the status of the IUCAF sciences in the degree of protection that the ITU Radio Regulations afford. Not only will changes in the frequency allocations be proposed by other services, but also as other services increase their usage of bands throughout the spectrum so will the likelihood of interference to passive services increase.

As has already been explained, the most serious immediate difficulties will face radioastronomy, but space research will also need attention.

The means by which scientific and technical information can be formulated and supplied to the ITU is through the work of the CCIR. This is a regularly scheduled and ongoing task carried out by study groups, working parties etc., and the output is presented at CCIR Plenary meetings. Input to the CCIR is from the various Administrations which join in the work. To make this input effective in, for example, radioastronomy it is essential that in countries with strong radioastronomy programs there is direct interchange from scientists to the part of the administration working with the CCIR.

In a parallel manner, the discussions which take place within an administration while a WARC is being planned must allow for input in a fairly formal way from the scientists to the administration. Once a WARC is in progress, if matters of serious scientific importance arise, well-managed administrations will see to it that their delegates at the WARC are assisted in making correct choices.

But it will be obvious that these tasks of laying good scientific and technical ground-work with the CCIR and of making both careful preparation before a WARC and having a well-briefed delegation at a WARC are serious and difficult. The IUCAF experience shows that only a few administrations are able to fulfil these objectives.

It would seem that IUCAF should be able to lead in simplifying these processes. Again, using radioastronomy as an example, IUCAF has been able in the past to generate well before a WARC a position paper which carries an international agreement on what radioastronomers hope for at the WARC's end. This process worked reasonably well up to the conclusion of the 1979 WARC. But, for example, at the WARC MOB-87 questions arose on sharing an allocation between a mobile service and radioastronomy. An unsatisfactory conclusion was reached (see para. 4(a)); this suggests that the IUCAF mechanism may be unable to help in the much faster-moving world.

If ways could be found to improve the links within countries

between scientists and their administrations it might be that some of the agreed international opinions could be taken into consideration at an earlier stage. One very welcome development is the radioastronomers meetings in Europe (para. 4(c)). if one or more such regional associations were formed the co-ordination of opinions could be much improved.

Lastly, IUCAF has concluded that the number of members appointed by URSI and the IAU should be increased from two to four. This would make the membership eight for radioastronomy and two for space research. At present this change has been presented to URSI and if approval comes from the IAU and COSPAR it is likely to come about. It recognises the need for more help from radioastronomers around the world.