Commission 28: Galaxies

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This report coveres the period 1 July 1993 to 30 June 1996. In contrast to reports from previous triennia, which were written by commission officers, committee members, and chairs of working groups, all members of the comission were invited, through a newsletter, to volunteer to write sections on topics that interested them. About a dozen people volunteered, not all of whom were able to complete the reports they had suggested.

1. Highlights since the Hague
(V. Trimble)

In a typical year, the astronomical community now publishes more than 1000 papers that are indexed under "galaxies" in Astronomy and Astrophysics Abstracts and another 1500 under various headings representing active galaxies and clusters of galaxies; and their definitions are, if anything, narrower than ours. Every one of those papers is exciting to someone (at least the authors), and we cannot do even remote justice to them all here. To save space, references are given with only one or two authors' names (and + for "et al."), no year, and journal names maximally compactified, or as abstract numbers from AAA.

The last Comm. 28 report ended with a prediction that five areas would show major progress between 1993 and 1996. These were (A) the understanding of cooling flows in clusters, (B) lensing and microlensing of quasars (as a measure of H among other things), (C) correlations of globular cluster populations and their parent galaxies, (D) central massive black holes in active and normal galaxies, and (E) the universality (or not) of the galaxy luminosity function. Comments on each of these follow. Additional areas where something exciting seems to have happened include (F) active galaxies (hosts, starbursts vs. black holes, and unification), (G) X-Ray cluster gas composition, (H) high redshift galaxies, (I) the opacity of spiral disks, (J) galaxies in voids, (K) gas content of galaxies, (L) clusters and the evolution of clustering, and (M) galaxy classification and morphology.

Among the topics covered last time that will not be discussed again are dynamos, faint blue galaxies, large scale deviations from homogeneity and Hubble flow, extreme uv and gamma-ray sources, alignments of optical and radio structure QSO absorption lines (except as relevant to primordial galaxies), the enormous importance of mergers and interactions in triggering star formation and active nuclei, and the diffuse X-ray background contributed by galaxies and AGNs.

And there are still other important areas that are not highlighted in either report, including many issues of kinematics and dynamics (causes of spiral arms and bars, shapes of ellipticals, warped disks, rings and shells), IRAS galaxies, many aspects of nuclear activity (accretion disk structure and instabilities, jet and counterjet acceleration, source confinement, spectra and variability superluminal sources, the similarity of the nucleus of M81 to Sgr A*), much of stellar populations and population synthesis, and interesting large scale structure in interstellar gas like superbubbles and giant HII region.

I. Appenzeller (ed.), Reports on Astronomy, Vol. XXIIIA, 431–476.

A. COOLING FLOWS AND THE BARYON DENSITY PROBLEM

Many clusters of galaxies harbor diffuse gas at temperature $\geq 3 \times 10^6$ K, set by the depths of their potential wells and such that most of their emission is at X-ray energies. Quite often, the luminosity of (at least) the central region is so large that the gas cannot have enough stored energy to keep shining for the age of the universe. Thus the gas must be cooling and so (pushed by the overlying material) be flowing inward at rates of 10-1000 M_o per year. The 1250 M_o/yr reported by Edge + (MN 270, L1) may or may not be a record.

A feeling as the triennium went on that this topic was ripe for review was confirmed by the appearance of an excellent one (Fabian ARA&A 32, 277). An important recent development emphasized that satellite data from the post-Einstein era show directly that some cluster gas really is cooler at the center (David + ApJ 428, 544 on the NGC 5044 group, Irwin & Sarazin ApJ 455, 497 on 2A 0335+096, both with ROSAT; ASCA can do even better, Tsao + ApJ 429, 111). Such a configuration is clearly unstable, and there seem to be only three possibilities: (a) kinetic energy is somehow being continuously supplied to the gas from outside, (b) the gas continues to cool and so must eventually turn into other detectable phases, or (c) we are all making some terrible mistake.

Tempting as (c) may be, it is probably wrong. The gas is independently seen as a cause of large rotation measures of central radio sources (Taylor + AJ 107, 1942, Zoabi + ApJ 460, 244), through its interactions with the structure of these radio sources (Zhao + ApJ 416, 51), and perhaps as an absorber of soft X-rays (Voit & Donahue ApJ 452, 164). One possible alternative morphology is even more unstable and yields the wrong spectra as well (Fabian + ApJ 425, 40).

The mechanisms suggested to reheat the gas include conduction, the drag of passing galaxies, and various plasma instabilities (Deiss & Just A&A 301, 407, Pistinner & Shaviv ApJ 459, 147, Christodoulou & Sarazin ApJ 463, 80). That reheating does occur seems likely from some of the post-Einstein data, for instance the BBXRT and ROSAT views of Abell 2256 (Miyaji + ApJ 419, 66). It is generally sufficient only to slow the flow a bit, not to halt it. A few clusters are actually hottest at the center (Markevitch ApJ 654, L1), owing perhaps to merger-triggered shocks or convection, and they do not have cooling flows!

In general, however, we seem to be left with alternative (b), that the X-ray gas must be transformed into something else. What becomes of it? It should pass first through a coronal ($\sim 10^6$ K) phase. A characteristic coronal line of [FeX] reported in one cluster (Donahue & Stocke ApJ 422, 459) has not been confirmed (Yan & Cohen ApJ 454, 44). A possible EUV detection (Lieu ApJ 458, L5) in four clusters may represent a calibration error (Fabian Sci. 271, 1244).

The next temperature plateau at 10^4 K is associated with optical emission that will, however, be bright enough to see only where the gas is highly clumped. Some central galaxies of cooling flow clusters do have gas filaments in that temperature range (Fabian A&AR 32, 277, Edge + MN 270, L1), but the mass involved is tiny compared to the expected supply.

HI can also be limited quite severly. A recent absorption study (Dwarkanath + ApJ 432, 469) fully confirms earlier unsuccessful searches for 21 cm emission. Neutral gas is absent, down to a level about 1/30 that expected from Einstein X-ray data and models.

Molecular gas can be hunted for either indirectly as infrared emission by its dust (Annis & Jewitt MN 264, 543) or directly as a source of CO emission (Antonnucci & Barvainis AJ 107, 448, McNamara & Jaffe A&A 281, 673, O'Dea + ApJ 422, 467, Braine & Dupraz A&A 283, 407). These papers report only upper limits, ranging from 10^{10} M_o down to 4×10^7 M_o. If you think you know a time scale for cool gas to turn into stars, then you can translate these numbers into much less (0.01 - 0.1) gas than you were expecting. Alternatively, you can conclude that

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the gas must pass through the molecular phase in 10^7 yr or less. Gas very close to $T = 2.735$ K is, of course, almost undetectable in emission or absorption, and this is conceivably part of the answer (Ferland + MN 266, 399). An interesting exception is the Perseus cluster, whose central galaxy NGC 1275 (of which more shortly) does radiate in the CO lines. A map suggests that some of the gas has indeed dropped out of a cooling flow (Reuter + A&A 277, 121). If black holes were swallowing 100 M_o/yr or more in these clusters, you would already have noticed the effects.

Thus star formation is the last refuge of the cooling gas. Again, you would already know about it if this much material were being turned into a stellar population with its fare share of high-mass, bright blue members. Blue and UV colors and spectral signatures of young stars indicate that only 5-15% of the cooling flow mass is typically going into stars with a normal IMF (Crawford & Fabian MN 265, 431, Schombert + ApJ 416, L61, Cardiel + MN 277, 502, Allen MN 276, 947, Van Dyke AJ 111, 130).

Sherlock Holmes said that, whenever you have eliminated the impossible, whatever remains, however improbable, must be the truth. What remains for the cooling flows is the formation of (almost exclusively) low-mass stars. Whether star formation theory "predicts" this is a little difficult to say in the present nebulous condition of star-formation theory. But if the young and intermediate-age globular clusters at the center of NGC 1275 are indeed the descendants of cooling flow gas, then their apparent deficiency in massive stars may be offering a "yes" answer (Nørgaard-Nielsen + A&A 279, 61). One could, at least in principle, look for a vast number of sub-solar-mass stars in central elliptical galaxies using as a tracer the 2.3 μ CO feature that is diagnosic of light from dwarf stars dominating light from giants (Kroupa & Gilmore MN 269, 655).

Individual galaxies, like Cygnus A, can also have cooling flows (Reynolds & Fabian MN 278, 479). What about the Milky Way? Could high velocity HI clouds be an analog? Some of them have roughly the right properties (Danly + ApJ 416, L29). Sadly, however, all right thinking people clearly believe that the HVCs are part of and up-and-down flow driven by supernovae in the galactic disk (Little + ApJ 427, 267, Schulman + ApJ 423, 180). Perhaps at least we had one in the past. Fabian & Nulsen MN 269, L33, Nulsen & Fabian MN 277, 561) propose that part of the basic process of formation of large galaxies is a cooling flow that leaves them all with halos of brown dwarfs.

The X-ray emitting gas in cooling flow and other X-ray clusters (virtually all the rich, nearby ones and some small groups) is, of course, part of the baryon inventory of the universe. Nucleosynthetic considerations limit that inventory to 10% or less of closure density (for H = 50 km/sec/Mpc; it scales as H^{-2}, Copi + Sci. 267, 192. This leads to a contradiction if you believe that the X-ray clusters all have 20-30% of their mass in gas and that this ratio applied to all the matter in universe, and that the true total density is the critical one.

A large number of papers in the triennium have reported gas fractional masses of 15% or more (White & Fabian MN 273, 72, Elbaz + A&A 293, 337, Buote & Canizares ApJ 457, 568, Irwin & Sarazin ApJ 455, 497, Markevitch + ApJ 456, 437, Davis + ApJ 444, 582, Bardelli + A&A 301, 435, Squires + ApJ 461, 572, Henriksen & White ApJ 465, 515). Other papers have reported smaller gas gractions (Bryan + ApJ 437, L5, Dell'Antonio + AJ 110, 503). There is some tendency for small groups to have most of their baryons in galaxies rather than in gas (David + ApJ 445, 578, Pildis PASP 107, 1259, Mulchaey + ApJ 465, L5 & 80), but it is not universal (Davis + ApJ 460, 601).

Panic is, nevertheless, probably premature. First, the universe may not be closed (at least by baryonic + non-baryonic matter). Second, the rich clusters do not make up most of the luminous stuff, and their baryon fractions may not be typical. Third, the derived gas masses and total masses are based on rather simple models of the clusters, which may yield erroneously high gas masses and/or erroneously low total masses (Zabludoff & Zaritsky ApJ 447, L21, Kim + ApJ 441, 182, Deiss & Just A&A 301, 407, Schindler A&A 305, 756). There is some evidence for the last point in data derived from gravitational lensing (next section).

B. GRAVITATIONAL LENSING

The bending of light from background stars and galaxies by foreground stars and galaxies was anticipated from about 1800 onward and finally seen in the 1970s (initially with the background source being a quasar and the foreground lens a galaxy and/or cluster). Radio waves (etc.) will, of course, behave exactly the same way. We can now distinguish several cases (a) strong lensing, where you see two or more separated images (five is normal, but one or more often faint), (b) weak lensing, where you see amplification and rings or distorted images but not discrete images, and (c) microlensing, where a star (etc?) in the lens galaxy (including ours) passes across your sight line, changing things quickly. Other examples, including lensing of the 3K background and MACHOs,clearly belong to the subject matter of other commissions.

Weak lensing by clusters provides a check on the masses derived from X-ray emission and from the dispersion of galactic radial velocities in the cluster. As a rule, when you use both weak lensing and some other method, the total mass found from lensing is the biggest, often by factors of three or more (Loeb & Mao ApJ 435, L109, Fahlman + ApJ 437, 567, Carlberg ApJ 437, 63, Wu ApJ 436, L111, Miralda-Escude & Babul ApJ 449, 18), though there are exceptions (Allen + MN 279, 615). Evidently, gas does not always precisely trace the actual gravitational potential, as a result of mergers or other disturbances (Smail + MN 277, 1), a phenomenon occasionally called the Limber effect (Sadat ASS 234, 303), for Nelson. The total implied mass per galaxy is sizable, something like 8 X 10^{12} $M_{\odot}$ (Fahlman + ApJ 437, 567), but the X-ray emission from two Coma galaxies suggests that this really is the right answer, at least some of the time (Vikhlinin + ApJ 435, 162). Although cluster masses from weak lensing are generally regarded as the most reliable, they can be too large because of projection effects (Kneib + A&A 303, 27) or too small because of the effects of astronomical seeing (Wilson + MN 280, 199). At least a few clusters as large as local rich ones already existed by z = 1.2 and were distorting images of still more distant galaxies (Smail & Dickinson ApJ 455, L99). Techniques for optimal use of weak lensing data are still under development (Schneider A&A 302, 639)

Although new, strongly lensed quasars and galaxies continue to be discovered at ever larger redshifts (Fassnacht + ApJ 430, L130), surveys from both ground and HST continue to show that they are rare (Kochanek + ApJ 452, 109, Ratnatunga + ApJ 453, L5). Because lensing amplifies the flux you see, it is bound to contribute some apparent association of quasar and galaxy positions on the sky in any flux-limited sample. Just how much remains under discussion (Seitz & Schneider A&A 302, 9, Wu & Fang ApJ 461, 55, Fort + A&A 310, 705, Thomas + MN 273, 1069, Zang AJ 109, 56, Benitez & Martinez-Gonzalez ApJ 448, L89, Wu & Han MN 272, 705). An obvious signature, not much discussed, is that QSOs with absorption lines should look brighter on average than the others (Draskikh & Draskikh Astron. Rep. 39, 143).

The IRAS galaxy FSC 10214+4724 has been claimed as the brightest in the universe (at least for some combinations of H and q; its redshift is 2.28). It is, however, almost certainly lensed by a gE galaxy near z = 1 (Graham & Liu ApJ 449, L29, Broadhurst & Lehar ApJ 450, L42, Scoville + ApJ 449, L109). and the counterimage has been seen (Close + ApJ 452, L9, Reisenhardt + ApJ 461, 72). Even for the maximum likely amplification, the galaxy remains very bright (Trentham + MN 277, 616) and its gas content very large, since the CO emission is too extended to be much lensed. Lensing of CO emission occurs in other contexts (Casoli + A&A 360, L41), and in at least one case the redshift of the lens has been determined from a molecular

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absorption line (Wiklind & Combes Nat. 379, 139).

Einstein rings - lens images that are complete or nearly complete annuli - were first reported at radio wavelengths. At least one optical case is now known (Warren + MN 278, 139). Fritz Zwicky was a pioneer in predicting the existence of gravitational lensing and its importance in astrophysics, more than 40 years before the first case was found. He pointed out that images might be amplified so much that lensing acted like a telescope, enabling you to study galaxies otherwise too faint to do much with. The first one to be imaged this way, 0024+1054, is a very strange shape indeed (Colley + ApJ 461, L83), though not quite unprecedented (Morgan PASP 70, 304).

Finally, microlensing has been claimed as the cause for at least some of the variability we see in obviously (macro)lensed and other AGN (Romero + A&A 301, 641, and many other papers). Extreme versions of the hypothesis attribute all BL Lac objects (Stocke + ApJ 454, 55) and all QSO variability (Hawkins MN 278, 787) to microlensing. A signature for microlensing vs. intrinsic variability may exist when light curves with a few seconds temporal resolution become widely available (Jarosynski & Paczynski ApJ 455, 443).

Incidentally, the 1993 prediction that the triennium would see at least one microlensed quasars well enough understood that the time lage between components would tell us an independent, reliable value of H has not be fulfilled.

C. FAMILIES OF GLOBULAR CLUSTERS

Basic properties of cluster systems have been established for some time. These include a specific frequency (number per unit luminosity of the parent galaxy) that is higher for ellipticals than for spirals, and highest of all for central cD galaxies; a radial distribution that is more extended than that of field halo stars; and colors that are bluer than the field at the same radius, meaning lower metallicity. The most massive galaxies have the highest-metallicity clusters. Recent work continues to find these trends in additional galaxies (Grillmair + AJ 108, 102, Pritchett + AJ 107, 1730, Geisler + AJ 111, 1529). The shapes of the cluster systems, relative to that of the parent galaxy, also vary with type (McLaughlin + ApJ 422, 486, Kissler-Patig + A&A 308, 704).

Two current hot topics in applied clusterology are their use as a standard candle for measuring galaxy distances and their significance as tracers of galaxy formation (top down vs. bottom up, or whatever). The distributions of globular cluster luminosities are surprisingly similar from one galaxy to another. But M 31 peaks at M_V = -7.6 vs. -7.3 for the Milky Way (Reed + AJ 107, 555). This spread in peak values is just large enough to entitle you to put the Virgo cluster at either a long-scale or a short-scale distance (Kissler + A&A 287, 463). And there seem to be systematic differences. In M87, the distribution of cluster metallicity is bimodal (as it is for NGC 4472, Geisler AJ 111, 1529, and probably others), and the two groups have different luminosity distributions (Elson & Santiago MN 278, 677, MN 280, 971). Most serious of all, work on galaxies in the Fornax cluster indicates that peak luminosity is fainter for galaxies in dense environments (Blakeslee & Tonry ApJ 465, L19). It is easy to think of tidal-type explanations for the correlation, although the central galaxy identified with Fornax A does not seem to be a very good example since its globulars extend up to $10^7 L_\odot$ (Shaya + AJ 111, 2212).

The previous triennium saw a good deal of enthusiasm for the idea that globular cluster formation is triggered by mergers, thereby accounting for the higher specific frequency in ellipticals and cDs (and also, of course, favoring merger scenarios for formation of these types of galaxies). Evidence in favor of this sort of process has continued to trickle in (Zepf & Ashman MN 264, 611, West + ApJ 453, L77, Kumai + ApJ 416, 576, Perelmuter ApJ 454, 762), an important contributor being the presence of what look like young globulars in clusters showing

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other evidence for recent mergers (Whitmore + AJ 106, 1354, Schweizer & Seitzer ApJ 417, L29, Hunter + AJ 108, 84, Conti & Vacca ApJ 423, L97). There are, however, also reasons to climb down from the bandwagon, including the low specific frequency of NGC 1275 (despite the presence of young clusters, Kaisler + AJ 111, 2224), low S in at least four central cD galaxies in poor clusters (which must nevertheless have experienced lots of mergers, Bridges & Hanes ApJ 431, 625), and the high specific frequency of at least some dwarf spheroidals (van den Bergh AJ 110, 2700). One of these, the Fornax dSph, has enough clusters to display its own second parameter effect (Smith + AJ 111, 1596).

D. CENTRAL BLACK HOLES

Black holes at the centers of active galaxies have been part of the paradigm since 1964. Demonstrating the presence of a large, compact mass requires images and spectra of very high angular resolution. Thus it was expected that HST would advance our knowledge of these configurations. The case of M87 drew the most publicity. The HST data (Ford Nat. 369, 345, Ford + ApJ 435, L27, Harms + ApJ 435, L35) imply much the same mass, $2.4 \pm 0.7 \times 10^9$ M_o, as the best ground based data (van der Marel MN 270, 271) but give us greater confidence that the central object must be a single one, rather than some compact cluster. Comparably good cases can be made for M31, M32, and NGC 3115 (Kormendy AIP 254, 23, van der Marel MN 268, 521, MN 271, 99, Qian + MN 274, 602, Dehnen MN 274, 919, Tremaine AJ 110, 628, Bender + ApJ 464, L123, Kormendy + ApJ 459, L57) with masses of $1\text{-}2 \times 10^6$ for M32, 7×10^7 for M31, and 2×10^9 for NGC 3115. Other suggested cases include a number of galaxies examined by the pre-fix HST (Crane + AJ 106, 1354), NGC 1399 (Stiavelli + A&A 277, 421) and NGC 4594 (Seller + A&A 285, 739). If you know and love these galaxies, you will recognize that there is not much correlation between existence or mass of the BH and current activity level. There is, however, some evidence that galaxies currently seen as Seyferts and Liners have relatively low mass BHs, less than 10^7 M_o (Sergeev Astron. Rep. 38, 162, Perola & Piro A&A 281, 51, Bao & Østergaard ApJ 422, L51, Iyomoto + PASJ 48, 237). Even dwarf spheroidals could be hiding such beasts (Strobel & Lake ApJ 424, L83).

One normally supposes that a galaxy that once has a black hole will have it forever, and modellers can therefore justify their existence by explaining the lack of activity in most large galaxies now (Fabian & Rees MN 277, L55 and many others). The alternative is that the black holes are just passing through, being really an intergalactic population, whose occasional encounters with galaxies give rise to activity (Fukugita & Turner ApJ 460, L81).

Two other very different sorts of evidence for black holes in moderately active galaxies surfaced during the triennium. First, the very broad, asymmetric X-ray emission lines of MCG 6-30-15 may be a result of gravitational redshift (Tanaka + Nat. 375, 659, Corbin ApJ 447, 496).

Second is the very intriguing case of NGC 4258, whose central 0.1 pc is studded with water maser sources. The fabulous angular resolution provided by radio interferometry has permitted a map of their velocities vs. position. It looks remarkably like a map of Keplerian rotation in a disk with a central point mass of $2\text{-}4 \times 10^7$ M_o (Watson & Wallin ApJ 432, L35, Hascheick + ApJ 437, L35, Miyoshi + Nat 373, 127). The components should be moving at about 35 μarcsec/yr, detectable in VLBI images over the next triennium. That the motion has not already been seen implies a lower limit to the source distance of 5.4 Mpc (Greenhill + MN 274, L59, ApJ 440, 6±9), though a typographical error has converted the limit in one of the abstracts to 5.4 pc, which we never doubted.

The nucleus of M31 has been resolved into two, unequal components (Shaya + Sci. 261, 422), each of which could presumably harbor a black hole (Lauer + AJ 106, 1436, Bacon + A&A 281, 691). Binary nuclei are probably fairly common in bright galaxies (Schmit + MN 278, 965, Clements + MN 279, 511, Larkin + ApJ 452, 599, Kotilainen A&A 305, 107), and there have been several models suggesting binary black holes as the best explanations of the behavior of OJ 287 (Lehto & Valtonen ApJ 460, 207) and 3C 390.3 (Gaskell ApJ 464, L107) as well as several simulations of the merger process (Valtonen MN 278, 186, Makino & Ebisuzaki ApJ 456, 527).

The 3.4 hour period object that pretended to be Seyfert galaxy NGC 6814 is in fact a cataclysmic variable (Staubert + A&A 288, 513), but has been replaced by a possible 0.9 day period in RX J0437.4-4711 (Halpern & Marshall ApJ 464, 760).

E. LUMINOSITY FUNCTIONS

Our favorite new luminosity function is that of radio luminosities of radio-quiet quasars (Kellermann + AJ 108, 116, Blundell & Lacy MN 274, L9, Papadopoulos + ApJ 446, 150), which is not an oxymoron but a genuine triumph of technology. They are a separate population from the rarer, radio loud ones, though the spectra are not very different (Barvainis + AJ 111, 1431). A number of broad absorption line quasars, not found among radio loud objects, are represented.

Three questions that have been around for a long time, and on which the final answer is clearly not in,concern the universality (or the opposite) of the optical luminosity function of normal galaxies, the possibility that we might be missing a large fraction of the total galactic light and mass in the form of dwarf or low-surace-brightness galaxies, and the evolution of the luminosity function as we look back to large redshift.

A preliminary answer to the faint galaxy question is that there are indeed a great many of them in clusters (with more or less the same ratio to numbers of giant ellipticals in Coma and Virgo), but that the total contribution to light and mass is, at most, at the 10-30% level (Kashikawa + ApJ 444, L95, Bernstein + AJ 110, 1507, Drinkwater + MN 279, 595, McGaugh MN 280, 337, Secker PASP 105, 550). And dwarf spirals are very rare indeed (Schombert + AJ 110, 2067).

No one doubts that galaxies were different in the past. The argument about density evolution vs. luminosity evolution, based on number counts, has flourished for decades (as did that about radio sources a generation ago). A definite answer awaits redshifts for large numbers of galaxies in the Hubble Medium Deep Survey (Im + ApJ 461, L79) and from the Hubble Deep Field.

Meanwhile, there seems to be general agreement, from ground-based work extending to about z = 0.75, that a great many entities that used to be faint blue (tar-(star-forming) galaxies, compact narrow-emission-line galaxies, and such are so bright and blue as they were. They have faded to low surface brightness galaxies, from Sd's to dSph's, or some other inconspicuous form (Ellis + MN 280, 235, Babul & Ferguson ApJ 458, 100, Moore + Nat. 374, 613, Guzman + ApJ 460, L5, Gardner MN 279, 1157, Lin + ApJ 464, 60)

There is less agreement about the amount and kinds of changes in the luminosity function for galaxies brighter than what is now L*, the bend in the distribution. Near the upper, z = 0.5-0.75, end of the redshift range under consideration choice of q begins to make a difference in the results. Safe statements seem to be (1) both ellipticals and spirals were at least somewhat brighter at moderate redshift than they are now (Forbes + ApJ 462, 89, Bender + ApJ 463, L51, Schade + ApJ 463, L63 and 465, L103), (2) the difference is larger in the ultraviolet (Oke + AJ 111, 29), and (3) the difference is not enormous (Vogt + ApJ 465, L15). Most known high redshift ellipticals seem to be very dusty, which complicated interpretation of the observations (Mazzei & De Zotti MN 279, 535).

Explanation is even more precarious than observation, but something like passive evolution (gradual dying away of star formation) seems to be capable of explaining data over small to moderate redshifts (Lilly + ApJ 460, L1, Lubin AJ 112, 23). Since we all also believe in the importance of mergers and triggering of star formation thereby (which will mean that galaxies should be getting less numerous but brighter), further work is clearly required!

F. ASSORTED ACTIVE GALAXIES

1. Quasar Hosts

The discovery of quasars in 1963 quickly spawned the suggestion that they were associated with bright galaxies, by analogy with Seyfert and N-type galaxies, known since 1943 and 1958 respectively. This necessarily put them at the distances indicated by their redshifts. The counter-proposal of local quasars quickly followed. The opposing ideas make at least one clear prediction. If QSOs are nuclei of normal galaxies, then you should be able to see the galaxies and their near neighbors by working hard. If not, not.

A handful of hard workers had put several faint galaxies and at least one very bright one within the confines of clusters of galaxies at the same redshift by 1972. Fuzz of the right size and color to be bright elliptical galaxies surrounding the point sources followed shortly (Kristian ApJ 176, L47). Most of us then lost interest in the problem for about 20 years, though acquiring along the way a strong feeling that radio-loud quasars live in elliptical galaxies, as do the lower-redshift strong radio sources in 3C and other catalogs, while the radio quiet ones live inside spirals.

Interest revived with the advent of HST and its potential for resolving faint structure close to bright points, perhaps to the extent of revealing host morphological types and permitting redshift measurements. Some things haven't changed. Seyferts and LINERS are still spirals (Moles + ApJ 438, 604, McLeod & Riecke ApJ 441, 96), often with companions; while radio galaxies are still ellipticals, despite one major false alarms (Veron & Veron-Cetty A&A 296, 310, Colina & de Juan ApJ 448, 548).

Ground-based optical and near-infrared observations of "objects generally recognized as QSOs" continue to show a general pattern of radio = elliptical and brighter than L*, while radio quiet = spiral and rather fainter, though both are likely to have mission lines (Durret + A&A 291, 392, McLeod PASP 107, 9, McLeod & Riecke ApJ 441, 96, Neugebauer + ApJ 455, L123). The maximum redshift for quasar fuzz seen from earth has grown to z = 2.3 (Aretxaga + MN 275, L27) and hosts of a wide range of morphological types have been reported for BL Lac objects (Falomo + ApJ 438, L9, Benitez + ApJ 463, L47, Wirtz + ApJS 103, 109).

Next come a few objects that used to be called radio galaxies (more or less elliptical in shape) or IRAS galaxies (any old shape, with lots of dust and gas), but which have recently been promoted to quasars on the basis of broad absorption lines or other evidence for hidden nuclei, analogous to Seyfert 2 galaxies being Seyfert 1's with hidden cores. The best known is Cygnus A (Antonucci + Nat. 371, 311), followed by 3C 22 (Economov MN 272, L5) and some IRAS galaxies (Lonsdale + ApJ 438, 672). Since we already knew about the galaxies, if they are really quasars on luminosity or other grounds, then they clearly have hosts!

Imaging of QSO hosts with HST got off to a rocky start, with an initial report of no extended emission around any of four QSOs at z = 0.16 to 0.24 (Bahcall + ApJ 435, L11) at limits somewhat below L*. It now seems probably that this was a result of the choice of image smoothing techniques (McLeod & Riecke ApJ 454, L77(, and all subsequent reports have included some detections. These include two z = 0.3 objects (one radio loud, one radio quiet, Hutchings & Morris AJ 109, 1541), four low-redshift objects that look like giant ellipticals (Disney + Nat. 376, 150), including one QSO in common with the Bahcall et al. sample, five detections out of six z = 2 sources (Hutchings AJ 110, 994), with the radio quiet hosts fainter than the radio loud ones by about 2^m, and two more low-redshift, radio quiet QSOs in galaxies slightly brighter than L* (Bahcall + ApJ 457, 557)

2. Starbursts vs. Central Black Holes

A brief review near the beginning of the triennium (Trimble & Leonard PASP 106, 18) concluded that a large fraction of bright galactic centers have contributions both from rapid star formation and from an accreting black hole. Subsequent work has strengthened this conclusion. Seyfert galaxies characteristically have both stellar and non-stellar light, with proportions varying from object to object (ApJ 452, 549, Serote-Roos + MN 278, 897, Alonso-Herrero + MN 278, 902). IRAS galaxies similarly include objects dominated by star bursts and ones dominated by central engines, though there seems to be some real disagreement about whether the AGN population is 10% or 75% of the total (Rigopoulou + MN 278, 1049, Granato + ApJ 460, L11, Clements + MN 279, 419, Lancon & Thuan A&AS 115, 253).

The z = 2.29 IRAS galaxy F10214+4724 (which also appears in the lensing section) seems to be an extreme example of "both please" (Green & Rowan-Robinson MN 279, 884, Kroker + ApJ 462, L55, Lawrence + MN 260, 28). It might plausibly be also called a Type 2 quasar (by analogy with Type 2 Seyferts) with a hidden nucleus, of which there are other suggested examples (Almaini + MN 277, L31), including Cyg A mentioned above under host galaxies and some mentioned below under unification.

At least radio loud AGNs and the ionized gas near their centers definitely require a black hole + accretion disk contribution (Colina & Perez-Olea MN 277, 845, Eales & Rawlings ApJ 460, 68, Wang + A&A 304, 81). The idea of star collisions around a black hole (instead of an accretion disk) has recently been revived (Courvoisier + A&A 308, L17).

Lots of gas is, in any case, required to fuel both starbursts and black hole accretion (Gonzalez-Delgado PASP 107, 1130), and it is not entirely unreasonable to think of some sort of evolutionary relationship, in which gas compacted and stirred up by a merger first fuels a burst of star formation and the, when the dust has settled a bit, can be seen falling toward a central black hole. Periodic cycling between the two conditions has been proposed (Kundt ASS 235, 319).

3. Unification Schemes

Active galactic nuclei, if defined as galaxies with massive black holes in their cores, with accretion disks, magnetic fields, or some other mechanisms for using the BHs as energy sources, by definition have a good deal in common. Thus one ought to be able to account for the full range of their properties in terms of the range of variation of (a) central BH mass, (b) accretion rate, (c) field strength and topology, (d) nature of the environment provided by the parent galaxy, (e) the extent to which accretion takes place through a disk andoutgoing jets are collimated and (f) the angle from which we see all this. "Unification" generally means the attempt to attribute as much as possible to (f).

A brief review just before the start of the triennium (Trimble PASP 105, 8) reached the not-profound conclusion that orientation effects were important but not the entire story, either for the Seyfert 1/2 distinction or for the various types of more powerful AGN. A more recent review (Urry & Padovani PASP 107, 804) of the relationships between quasars and FR II radio galaxies and between BL Lac objects and FR I radio galaxies reaches similar conclusions and points to the angular momentum of the central black hole as an additional parameter that distinguishes radio loud from radio quiet activity.

Among Seyfert galaxies, the hosts of types 1 and 2 are very similar (Xanthopoulos MN 280, 6). Specific examples of type 2's for which polarization or ionization data suggest the presence of hidden nuclei and beamed ionizing radiation continue to be found (Gonzalez-Delgado & Perez MN 280, 53, Wilkes + ApJ 455, L13), and the X-ray emission from some type 2's looks like a reflection of that from typical type 1's (Smith & Done MN 280, 355). Nevertheless, it is probably not the case that every Seyfert 1, tilted on its side, would look like NGC 1068 (the prototypical type 2 with a hidden nucleus and BLR) and not every type 2 would untilt to a to a type 1 (Schmitt & Kinney ApJ 463, 498, Barcons + ApJ 455, 480).

Among the brighter AGNs, since the Urry & Padovani review (PASP 107, 804) there has been a proliferation of "Type 2 quasars", that is, objects (of which the prototypes are Cygnus A and IRAS F10214+4724) that, though now classified as various kinds of radio, starburst, FIR etc. galaxies, would be called quasars or QSOs as seen from some other direction (Simpson + ApJ 454, 683, Almaini + MN 277, L31, Tran + AJ 110, 2597, Ohta + ApJ 458, L57, Young + MN 279, L72). Among about 20 additional papers on the topic in the last year, those seeing correlations that are well explained by orientation effects almost exactly equaled the number of those pointing out discrepancies. There may or may not be a more definite answer by the end of the next triennium.

G. THE CHEMICAL COMPOSITION OF X-RAY CLUSTER GAS

It was, long ago, the discovery of iron emission features that settled the question of whether X-ray clusters were thermal or inverse Compton sources. Since then, attention has swung to measuring the metal abundance in the gas, its variations among and within clusters, and to figuring out where the heavy elements came from. ROSAT and ASCA data have enormously increased our detailed knowledge of total metallicity, metallicity gradients, and relative abundances of elements besides iron (Okozaki + PASJ 47, 399, Allen & Fabian MN 269, 409, Fukazawa + PASJ 46, L55, Loewenstein & Mushotzky ASP Conf. Ser. 88, 197). The total mass in heavy elements in the gas is quite considerable, and any model where the metals have been ejected from galaxies that still exist requires those galaxies to have lost about half of their initial baryonic mass. It is essential to take account the effects of cooling flow in modifying the distribution of metals through the clusters (Fujita & Kodama ApJ 452, 177, Reisenegger + ApJ 457, L11)

If the metals were produced by massive stars in galaxies that survive, they must surely have been blown out by supernova-driven winds (Matteucci & Gibson A&A 304, 11). The candidate sort of galaxies are naturally the ones we know about, spirals (probably not important, Fukumoto & Ikeuchi PASJ 48, 1), dwarf spheroidals (dominant according to Trentham Nat. 372, 157; blue compact dwarf galaxies at present do display winds with velocities of 2000-3000 km/sec, ApJ 458, 524), and giant ellipticals (dominant according to Nath & Chiba ApJ454, 524 and Elbaz + A&A 303, 345). One should probably reserve judgement, given that the chemical evolution of gE's themselves is not entirely understood (Gibson MN 278, 829; de Freitas Pacheco MN 278, 841) and presumably ought to be modified by the loss of whatever is blown out -- though we see the products only for gEs in X-ray clusters, the efficient of metal ejection is presumably the same for more isolated galaxies.

Finally, Rector + (AJ 110, 1492, and many other authors) have suggested that at least some clusters did not yet have an extensive intracluster medium at z = 0.5 (on the basis of undistorted radio source in them, or X-ray non-detections). For all the X-ray gas to be galactic ejecta is probably impossible, given that the gas normally outweighs the remaining galaxies, and one must postulate continuing infall.

H. GALAXIES LONG AGO AND FAR AWAY

Papers based on studies of galaxies in the Hubble Deep Field just begin to appear, and we will surely know much more about this topic by the end of the next triennium. Meanwhile, there has been some progress on two topics: (1) Are there any primordial galaxies? and (2) What, if anything, do QSO absorption lines tell us about formation and early evolution of galaxies?

1.Primeval Galaxies (?)

A primeval galaxy is an elliptical or a spiral bulge experiencing its first main burst of star formation, during which a large fraction of its stars form.

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Midway through the triennium, a review by Pritchet (PASP 106, 1052) concluded that none of these had yet been found. A slightly later mini-review (Trimble & Leonard PASP 108, 21) reported some additional non-detections and some candidates that don't really correspond to the definition (that is, they are not at large redshift and/or have a fairly modest star formation rate, or have clearly had previous star formation). Candidates in this sense continue to appear, with only moderate redshift (Cowie + Nat. 377, 603, Colley + ApJ 461, L83) or no particular evidence for rapid star formation (Yamada + AJ 110, 1564).

There is a good deal of evidence for relatively normal galaxies at quite large redshifts (Steidel + AJ 110, 2519, Smail & Dickinson ApJ 455, L99), including a new record redshift of z = 4.46 for a radio-loud quasar (Shaver + MN 278, L11) and perhaps even a very few redshifts larger than 5-6 in the Hubble Deep Field (Lanzetta + Nat. 381, 759, based on colors rather than spectra so far). Interpretation of these to yield an epoch of intense galaxy and star formation is, however, hampered by a good deal of degeneracy between composition and age when you have only integrated spectra of the galaxies (Mazzei & De Zotti MN 279, 535), so that the ages could be anything from 0.2 to 5 Gyr.

The most recent round of candidate primordial galaxies (in roughly the original definition) includes (a) a Lyman-alpha-emitting companion to a z = 4.7 QSO (Petitjean + Nat. 380, 411, Fontana + MN 279, L27, (b) a z = 2.7 galaxy with lots of OB stars, being seen less than 10^7 yr after its (first?) star burst; it is indeed very bright (Yee + AJ 111, 1783), has a scale length of about 3.5 kpc, and was found by chance in a redshift survey, (c) eight Hubble Deep Field candidates with redshifts of 2.6 to 3.9, which are bright, small, and disturbed (Clements & Couch MN 280, L43), and (d) detection by the traditional Ly-alpha emission method of two companions to a z = 4.55 quasar (Hu & McMahon Nat. 382, 231) and of a damped Lyman alpha absorber at z = 3.15 (Djorgovski + Nat. 382, 234). For all of these, the implied star formation rate is larger than the current 1 solar mass per year of the Milky Way, but smaller than you would need to make 10^{10} $M_{\odot}$ of stars in the time scale of Eggen, Lynden-Bell, and Sandage collapse. Steidel ♀ (ApJ 467, L17) note that star formation rate does not change much between z = 3 and 1, but morphologies do.

2. Clues from Quasar Absorption Lines

The gas responsible for QSO broad absorption lines (seen only in radio quiet sources) has solar metallicity or even a bit more, like the gas responsible for the emission lines (Turnshek + ApJ 463, 110, Tripp + ApJS 102, 239). This says that enrichment stars early and goes fast, at least in the centers of the largest galactic wells.

In contrast, the gas responsible for metal line systems and damped Lyman alpha lines (with redshifts very different from the emission ones) is generally metal poor. Majority opinion now holds that this gas is in the process of turning into stars within galaxies. First, the amount of gas present at redshifts near 3 is about the same as the amount of baryonic material now in stars (and the gas mass drops toward smaller redshfits). Second, the composition resembles that of old galactic stars (population II or thick disk) and metallicity gradually rises toward smaller redshift (Pei & Fall ApJ 454, 69, Wolfe + ApJ 454, 698, Lu + ApJ 457, L1, Tripp + ApJS 102, 239, Katz + ApJ 457, L17, Burles & Tytler ApJ 460, 584 Petitjean A&A 307, 417, Srianand ApJ 462, 643, Fukugita + Nat. 381, 489, Haehnelt + ApJ 465, L95). One group has, in fact, deliberately used the compositions of absorption lines as their input Z(z) for a model of galactic chemical evolution (Malaney & Chaboyer ApJ 462, 57).

This is not to say that the cloud gas is identical to interstellar medium gas today. In particular, despite some false alarms, neither 21 cm absorption nor CO is typically found (Carilli + AJ 111, 1830, Braine + A&A 309, L43) indicating that the gas is probably quite warm, perhaps 3000 K, unlike most galactic HI.

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There are a couple of other caveats. Gravitational lensing by the galaxy containing the damped Ly alpha clouds can mimic an increase of gas density toward high redshifts (Bartelmann & Weiss ApJ 457, 529). In addition, at redshifts less than 1.3, the absorbers evolve less steeply than at high redshifts and mimic the evolution of galaxies (Bahcall + ApJ 457, 19).

The nature of the gas clouds responsible for Lyman alpha forest lines and their relationship to galaxies remains in some dispute. All but the very weakest seem to have some metal absorption (Hu + AJ 110, 1526, Fernandez-Soto + ApJ 460, L81) and so must be located someplace where stars have formed and died. Multiple sight lines give the impression that the clouds are very large (50 kpc or more, Smette + A&AS 113, 19), but this is difficult to distinguish from a number of small clouds in a volume all at the same redshift. One unambiguously large cloud (Roettgering + MN 273, 389) seems to be in the host galaxy and so not relevant to the problem. The current majority opinion can probably be characterized by saying that Ly alpha forest clouds are associated with galaxies and trace the same large scale structure (presumably determined by the dark matter distribution) but as a rule are not actually galaxies or parts of galaxies (Rauch + ApJ 458, 518, A&A 306, 691, Srianand ApJ 462, 68, Fang + ApJ 462, 77, Muerket + A&A 308, 17).

I. OPAQUE GALAXIES(?)

There are two related issues here. First, could there be a significant population of high redshift quasars that we can't see because they are completely obscured by dust associated with absorption line gas? Second, could disks of spiral galaxies be so opaque that total luminosity is enough to account for their masses with a "stars only" mass to light ratio? Although the jury is still out on both issues, I think the answer is likely to be no, not really, for both. Some details:

The evidence for obscured quasars arises (a) from a handful of individual ones that are clearly much reddened by a known intervening galaxy (line absorber or lens Lawrence + AJ 111, 2570, Bartelmann & Weiss ApJ 457, 529, Stickel + A&A 306, 49) and (b) from statistical considerations of the extra-galactic UV background, chemical evolution, and so forth (Pei & Fall ApJ 454, 69, Fall & Pei in QSO Absorption Lines, 23). The most persuasive evidence against missing quasars and QSOs is the near-completeness of identifications of X-ray and radio sources in samples where the optical counterparts include a large percentage of quasi-stellars (Boyle & di Matteo MN 277, L63 on an X-ray sample, and the 3C catalog as a radio case). Those particularly interested in this topic will recall that it was sufficiently new at the 1994 GA that discussion was confined to an off-agenda gathering organized by R. Webster.

The spiral galaxy issue is, to a certain extent, a red herring, since most of the dark matter has to be far out, where there is no evidence for any star formattion or dust. The definitive test is, of course, to look for re-radiation in the infrared or millimeter regime (since the dust is expected to be very cold, perhaps 10-20 K). It is true that at least a few nearby galaxies are quite bright thermal millimeter sources, including the LMC (Dall'Oglio + A&A 303, 737) and NGC 4565 (Neininger + A&A 310, 725). A given amount of dust will be more serious if it is concentrated with the stars, as may be the case (Tovmassian + AJ 111, 306), so that simple models for deprojection based on correlations with sine *i* don't work (Kuchinski & Terndrup AJ 111, 1073, Di Bartolomeo + MN 277, 1279). There is, nevertheless, a certain amount of evidence that a large fraction of spirals have a face-on optical depths less than unity at visual, infrared, and even ultraviolet wavelength (Emsellen A&A 303, 673, Want & Heckman ApJ 457, 645, Buat & Xu A&A 306, 61, Giovanardi & Hunt AJ 111, 1086, Heraudeau + A&AS 117, 417). Incidentally, it is not quite obvious, but scattering reduces the amount of extinction produce by a given optical depth. The whole issue remains of some importance not only because of its implications for M/L ratios but also because unrecognized disk opacity can mimic evolution of faint galaxies (Leroy & Portilla ApJ 457, 145)

J. GALAXIES IN VOIDS

Galaxies in voids are a good deal like galaxies in other uncrowded regions, except that there are not so many of them (Weistrop + AJ 109, 981, Vennik + A&A 117, 261, Szomoru + AJ 111, 2141 & 2150). The same applies to the gas clouds (Shull AJ 111, 72).

K. GAS CONTENT OF GALAXIES

Probably no galaxy is truly gas free. Interesting questions includ the amount and dominant phase of gas in giant ellipticals (Knapp & Rupen ApJ 460, 271, Ciotti & Pellegrini MN 279, 240, Plana & Boulesteix A&A 307, 391) and the implications of that gas for cosmic ray acceleration by supernova ejecta encountering it (Dorfi & Voelk A&A 307, 715). Just how dwarf galaxies distribute themselves across the continnum from all stars to all gas is another puzzle (Matthews & Gallagher AJ 111, 1098). Just as galaxies with no gas are rare, large quantities of gas with no galaxy are also not common (Briggs + ApJ 415, L99).

We focus on two issues: the correct ratio of H_2 to CO to use in estimating total masses of molecular gas in various contexts and the recent detection of very large amounts of CO at large redshift. The standard Milky Way ratio is 2.3×10^{20} H_2 cm^{-2} (K km/sec)$^{-1}$, though individual clouds can deviate greatly.

Looking outside the Milky Way, we see most conspicuously a correlation of H_2: CO with gas compoisition -- lower metallicity = less CO. The correlation could be as steep as linear in O/H (e.g. Arimoto + PASJ 48, 275) or somewhat shallower (Wilson ApJ 448, L97). Galaxies more or less like ours, including M100 and NGC 4631, have similar H_2/CO ratios (Rand AJ 109, 2444, Braine + A&A 295, L55). In contrast, metal poor dwarf galaxies can have much larger ratios (Mulder + A&A 300, 687), up to 30 or more times the Milky Way standard (Verter & Hodge ApJ 446, 616).

At the other extreme, H_2/CO ratios smaller than the galactic one by factors of 2-10 must apply to an assortment of Seyfert, starburst, and IRAS galaxies or their centers, because otherwise you would find a molecular mass exceeding the entire dynamical mass of the galaxy or some other contradiction (Shier + ApJ 433, L9, Genzel + ApJ 444, 129, Mauersberger + A&A 301, 421, A&A 309, 705). Abundances in these galaxies are typically not very well known, and it is conceivable that they are sufficiently metal rich to account for the difference. It is perhaps more likely that the general high level of activity is responsible for more efficient heating of the CO and so for brighter emission from a given quantity of gas.

In light of the previous paragraph, one should regard with caution the precise amounts of molecular gas reported for very high redshift galaxies, quasars, and absorption line clouds. These scale, of course, with h^{-2} and in a more complex way with q, and have generally been derived by assuming the Milky Way H_2:CO conversion factor. That being said, molecular gas masses of 10^{11} M_o or more have been reported for 3C 48 (Scoville + ApJ 415, L75), F 10214+4724 at z = 2.28 (Tsuboi & Nakai PASJ 46, L179, Radford + AJ 111, 1021), the lensed BAL QSO H 1413+117 at z = 2.5 (Barvainis + Nat. 371, 586), a damped Lyman alpha absorber at z = 3.14 in the spectrum of PG 1643+4631A (Frayer + ApJ 433, L5) and a z = 2.4 primordial galaxy candidate (Yamada + AJ 110, 564). As a rule, radio galaxies are less gas rich than IRAS galaxies at the same redshift (Evans + ApJ 452, 658). A still more spectacular case of large amounts of CO at large redshift has received much attention in the popular press just outside the period covered by this review. The main points are that these detections show (a) the existence of bound, galactic mass entities very early and (b) early metal enrichment in contexts other than QSO nuclei.

L. CLUSTERS AND THE EVOLUTION OF CLUSTERING

A number of interesting things have been said about clusters of galaxies during the triennium. There are some remarkably big ones (e.g. Abell 3538 at the center of the Shapley concentration, Bardelli + A&A 301, 435). The structure of the

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Fornax cluster suggests the existence of two scale lengths and so two kinds of dark matter (Ikekbe + Nat. 379, 427). It can be argued that all clusters have the same mass to light ratio (Carlberg + ApJ 462, 32), and (though this has been disputed) that George Abell actually did a pretty good job of finding and classifying clusters (Katgert + A&A 310, 8).

A particularly interesting question is the numbers and sizes of clusters at moderate to large redshift, because these data ought to provide a direct answer to whether galaxy formation was primarily "top down" or "bottom up". It is clear by now that there are relatively few large X-ray clusters at z = 0.3-0.5 and larger (Roche + MN 276, L45, ApJ 424, L29, Sokoloski + ApJ 459, 142). In the optical regime, sampling errors can produce an artificial increase of clustering with redshift (Mann + MN 279, 636), and in fact there is probably a decrease (Le Fevre + ApJ 461, 534, Lidman & Peterson MN 279, 1357, Kennefick + AJ 111, 1816).

There are, of course, known groups and companion galaxies at z = 2-4 and more but they should perhaps be described as components in the process of merging to make large galaxies, rather than as ancestral clusters (Pascarelle + ApJ 456, L21, Francis + ApJ 457, 490, Hu + ApJ 459, L53). A claim has been made for significant superclustering on a scale of 4000-7000 km/sec at a redshift as large as two (Dinshaw & Impey ApJ 458, 73).

M GALAXY CLASSIFICATION AND MORPHOLOGY

Hubble types go right back to Edwin Hubble, and have stood the test of time remarkably well, though with additions and refinements added by G. de Vaucouleurs, S. van den Bergh, A. Sandage, and others. Of course no system is perfect. There are nearby galaxies whose spectra and shapes belong to different types (Zaritsky + AJ 110, 1602); warped SO's and E's can be confused (Maleldin ASS 234, 259); and several groups have proposed improved schemes based on parameters that are more closely linked to underlying physics than is the ellipticity of E's (Kormendy & Bender ApJ 464, L119). Nevertheless, a reinvestigation of spirals concludes that luminosity and bulge/disk ratio really are the right parameters (Magri AJ 110, 1614), and the traditional system is objective enough that a neural network has been "taught" to classify galaxy images about as reliably as six human experts could (Naim + MN 274, 1107; 275, 567).

More serious problems arise for galaxies at moderate to large redshift. The category tentatively called "chain galaxies" (Cowie + AJ 110, 1576), seems to have been a false alarm in interpreting low surface brightness galaxies seen edge on (Dalcanton & Shectman ApJ 465, L9). But a large fraction of the images in the Hubble Deep Field cannot be assigned to any specific Hubble type (except, perhaps, "irregular:!), and this applies also to high redshift objects found in other ways (Abraham + MN 279, L47, Colley + ApJ 461, L83).

N. AND ALL THE REST

A dozen or so short items (like highest redshift ROSAT galaxy, most distant water maser, third thick disk, fifth radio jet seen optically, and so forth) have appeared in the reviews cited previously PASP 106, 1; 107, 1; 108, 8), and many more culled be culled from the 2500 or so relevant papers published during the triennium, but this is left as an exercise for the reader.

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2. catalogs and atlases
(S. Okamura)

This report covers the material which appeared in *ApJS*, *ApJ*, *AJ*, *MNRAS*, *A&ApS*, *A&Ap*, *PASP*, *PASJ*, and *A.Nach.* during the period of mid-93 to mid-96 with a few additions. In addition to the catalogs and atlases of conventional style, papers which present original observational data for a significant number of objects are included.

1993		
Huchra+	The Center for Astrophysics redshift catalogue	*CfA*
Stanghellini+	Optical..imaging of GHz-Peaked-Spectrum..sources	*ApJS* 88, 1
Lu+	HI 21-cm obs. &.. photom.. galaxies behind Virgo..	*ApJS* 88, 383
Ryder+	An Hα atlas of nearby southern spiral galaxies	*ApJS* 88, 415
Granato+	A study of a..sample of opticall selected AGN.III.	*ApJS* 89, 35
Yamada+	A serach for IRAS galaxies behind..Milky Way	*ApJS* 89, 57
David+	A catalog of intracluster gas temperatures	*ApJ* 412, 479
Osterbrock+	Spectroscopic study of the CfA sample of Seyfert..	*ApJ* 414, 552
Fich+	Millimeter & submm continuum..from early-type gal.	*ApJ* 415, 75
Zepf+	The struc. & dyn. of E galaxies in compact groups	*ApJ* 418, 72
Chengalur+	Dynamics of binary galaxies. I. Wide pairs	*ApJ* 419, 30
Falomo+	The optical to near-IR emission of BL Lac obj...	*AJ* 106, 11
Tytler+	Lick..spectra of 38 objective prism quasar cand...	*AJ* 106, 426
Alonso+	CCD calib. of the mag. scale for... galaxy sample	*AJ* 106, 676
Hill+	Dynamics of cD clusters of gal.I. Redshift data...	*AJ* 106, 831
Drinkwater+	On the nature of MgII abs. line systems in quasars	*AJ* 106, 848
Condon+	The PMN surveys.IV. Maps for the southern survey..	*AJ* 106, 1095
Zabuldoff+	The kinematics of dense clusters of galaxies.I...	*AJ* 106, 1273
Crane+	High resolution imaging of galaxy cores	*AJ* 106, 1371
Pogge+	Star formation in the disks of HI-rich S0 galaxies	*AJ* 106, 1405
A-Salamanca+	Evidence for.. evol... properties of galaxies...	*MNRAS* 262, 764
Kotilainen+	CCD imaging of Seyfert galaxies: deconvolution of..	*MNRAS* 263, 655
Lacy+	A complete sample of sources in the NEP,..at 38 MHz.	*MNRAS* 263, 707
Dunlop+	Lum. dependence of optical activity..radio gal...	*MNRAS* 263, 936
Tadhunter+	Opt. spectr. of a..sample of...2-Jy radio sources	*MNRAS* 263, 999
Morganti+	The radio structures of southern 2-jy radio sources	*MNRAS* 263, 1023
van Haarlem+	The dyn. of the outer regions of the Coma cluster	*MNRAS* 264, 71
Dunlop+	Infrared imaging of the host gal. of..quasars	*MNRAS* 264, 455
Gear	Are there two populations of BL Lac objects?	*MNRAS* 264, 919
Carollo+	Metallicity gradients in early-type galaxies	*MNRAS* 265, 553
Oly+	..positions & 327MHz flux densities of UGC gal...	*A&ApS* 100, 263
Stickel+	Spectr. obs. of radio source identifications...	*A&ApS* 100, 395
Fouqué+	Dynamics of the Pavo-Indus and Grus clouds of gal.	*A&ApS* 100, 493
Sage	Molecular gas in nearby galaxies. II. The data	*A&ApS* 100, 537
Boisson+	Infrared and opt. photom. of gal. in four clusters..	*A&ApS* 100, 583
van Driel+	IRAS CPC obs. of galaxies. I. Catalog and atlas	*A&ApS* 101, 207
Galli+	Redshift of southern rich clusters	*A&ApS* 101, 259
Zenner+	Near-infrared images of IRAS galaxies	*A&ApS* 101, 363
Bondi+	Radio gal. of intermediate strength. II. VLA obs.	*A&ApS* 101, 431
Bursov+	The spectr. charact. of the RATAN-600.. sources	*A&ApS* 101, 447
Quintana+	Spectr. obs. of the galaxy cluster A3571	*A&ApS* 101, 475
Stickel+	Optical spectr. of 1 Jy, S4 & S5 radio sources.IV.	*A&ApS* 101, 521
Bottinelli+	Obs. data for the kinematics of the local universe..	*A&ApS* 102, 57
Machalski+	Deep optical id's of compact radio sources...	*A&ApS* 102, 315

Predes+	Opt. counterpart of galactic plane..radio sources	*A&ApS* 102, 381
Steppe+	Millimeter continuum meas. of extragalactic radio..	*A&ApS* 102, 611
Tresse+	..results from a deep spectr. survey of faint..gal.	*A&Ap* 277, 53
Briel+	X-ray emission from a..sample of Abell clusters...	*A&Ap* 278, 379
Le Brun+	..imaging survey of fields around quasars...	*A&Ap* 279, 33
Baffa+	Peculiar motions in superclusters: Perseus-Pisces	*A&Ap* 280, 20
Mack+	Observations of 10 tailed radio sources at 10.6 GHz	*A&Ap* 280, 63
Banfi+	HII regions in spiral galaxies: positions,...	*A&Ap* 280, 373
Buson+	The distr. of ionized gas in early-type galaxies	*A&Ap* 280, 409
Karachentsev+	Flat galaxy catalog	*A.Nach.* 314, 97
Stoll+	Photom. cat. of Shakhbazian..groups of gal.I.II.	*A.Nach.* 314, 225; 317
Schmidt+	Nearby galaxies. Revised machine-readable..catalog	*A.Nach.* 314, 371

1994

Sandage+	The Carnegie atlas of galaxies	(Carnegie Inst., Wash.)
Gregory+	The PMN map catalog of radio sources..at 4.85 GHz	*ApJS* 90, 173
Griffith+	The PMN surveys. III. Source catalog for..survey	*ApJS* 90, 179
Bechtold	The Lyman-alpha forest near 34 QSOs with z¿2.6	*ApJS* 91, 1
Wright+	The PMN surveys. II. Source catalog for..survey	*ApJS* 91, 111
de Juan+	Surface photometry of low-luminosity radio gal.	*ApJS* 91, 507
Ellingson+	A redshift survey in quasar fields. I. Photom...	*ApJS* 92, 33
Wilkes+	The EINSTEIN database .. of..quasars.I.	*ApJS* 92, 53
Collier+	The HII regions of NGC 6822.III..photometric atlas	*ApJS* 92, 119
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3. Dwarf Galaxies

Noah Brosch

Dwarf galaxies (DGs) are generally considered all M>-17 galaxies. These intrinsically faint objects are probably the most common galaxies in the (nearby) universe (Ferguson & Binggeli A&A Rev 6, 67). Their nature is now better understood because of new opportunities in the observational field, as multi-spectral data are integrated into coherent pictures, and as a result of better modeling.

DGs have different shapes. Dwarf ellipticals (dE, dSph) have smooth light distributions and are found in locations of high galaxy densities. Karachentsev + (A & A 296, 641) found large numbers of dSph in the central regions of the Coma cluster, which contains some 4000 dSph galaxies. Young & Currie (MNRAS 268, L11) defined a new distance indicator, linking the curvature of the surface brightness profile to the intrinsic luminosity of a dE. Driver + (MNRAS 268, 393) showed that in Abell 963 (z=0.206) the luminosity function at M(R)=-16.5 is steep, just as seen in nearby clusters. dEs are flatter than normal ellipticals. This was found for Virgo cluster (VC) DGs by Ryden & Terndrup (ApJ 425, 43), who showed that nucleated dEs are rounder than non-nucleated dwarfs. Vader & Chaboyer (AJ 108, 1209) measured exponential luminosity profiles for dEs; they may have evolved from more massive systems which lost mass by SNe, or may be by mergers. The late type DGs are diffuse irregulars (dIrr) with low surface brightness (LSB), or blue compact high surface brightness objects (BCDs). The morphology of some DGs in the JHK bands was studied by James (MNRAS 269, 76), who found that dIrr's are highly asymmetric and not relaxed, indicating a young age. Binggeli & Popescu (A&A 298, 61) found that dEs and smooth Irr's are slightly rounder than later DGs. LSBs have disky light distributions (Karachentseva + A&AS 117, 343), but Vennik + (A&AS 117, 261) found that faint galaxies are not Freeman disks.

The distribution of BCDs in the direction of the VC was studied by Drinkwater + (MNRAS 279, 595). Young & Currie (MNRAS 273, 1141) found significant depth of the dE distribution in the direction of Virgo; many dEs could be chance projections, or the VC may be a filamentary distribution of galaxies. The VC contains hot gas (X-ray emission in the W cloud: Davis + ApJ 444, 581; EUV emission: Lieu + ApJ 458, L5) but the W cloud is rich in BCDs. Is it possible that the presence of hot gas enhances star formation (SF) through enhanced external pressure ? Vilchez (AJ 110, 1090) showed that the degree of activity of a galaxy is connected with the density of its environment; DGs in low galaxy density regions show higher excitation and ionization and their Balmer lines have larger equivalent widths than DGs in higher density environments.

The clustering of LSB DGs was studied by Karachentseva & Vavilova. LSBs in the VC are distributed as the bright galaxies (Kin. Fiz. Neb. Tel. 11, 1), but in the Fornax cluster they are more concentrated than the bright galaxies (Kin. Fiz. Neb. Tel. 11, 60). In both clusters the LSBs avoid the central regions. Some LSBs in Fornax were studied by Cellone + (ApJS 93, 397); they are all dEs. Bothun + (AJ 106, 530) found a deficiency of nearby companions within 0.5 Mpc (projected) from LSBs. The more metal-rich a galaxy is, the larger it is and the higher is its

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surface brightenss. The luminosity profile of a galaxy correlates with its magnitude. A photographic search for DGs in Fornax was conducted by Demers + (AJ 108, 1648). The space distribution of BCDs was studied by Pustilnik + (ApJ 443, 491); the majority have neighbors within 5 Mpc though some are in voids. The lack of BCDs with neighbors within 2 Mpc indicates that a tidal origin of BCDs is not preferred.

Evolutionary histories were discussed by Gallagher ("From stars to galaxies"=FSTG). The influence of neighborhood was studied in Telles's PhD thesis (PASP 108, 462). BCDs in Virgo were studied by Almoznino (PhD thesis). SF histories were derived from broad-band and H-alpha photometry. Most could be explained by two populations formed in short bursts spaced by 1-2 Gyrs. In the amorphous DG N1705 Quillan + (AJ 110, 205) found a highly composite stellar population, with young stars mixed with an old stellar component. The chemical evolution of metals in DGs traces stellar evolution. Garnett + (ApJ 443, 61) measured an increase of C/O as the O/H ratio increases; this indicates delayed ISM enrichment by intermediate-age stars. In the youngest galaxies enrichment is from the most massive stars and these DGs are the most metal-poor.

Individual DGs studied in detail were I Zw 18 (Hunter & Thronson ApJ 452, 238; Dufour FSTG), Mkn 996 (Thuan + ApJ 463, 120), IC 10 (Massey & Armandroff AJ 109, 2470). Such DGs have low metallicities (Miller & Hodge ApJ 458, 467). In UGC 4483, a dIrr in the M81 group, Skillman + (ApJ 431, 172) found O/H low, but S/O almost solar. The He mass fraction was 0.239 ± 0.006, as from primordial nucleosynthesis. In the more extreme star-burst (SB) galaxies (the Wolf-Rayet class) significant light originates from short-lived, massive, highly luminous WR stars. The WR galaxies are observed at a very special moment of their development, when an intense SF burst is less than 10 Myrs old (Conti & Vacca ApJ 423, L97; Beck + (ApJ 457, 610); Kobulnicky + ApJ 454, 121; Conti + ApJ 461, L87). Supernovae (SNe) and stellar winds from a SB may completely drive off the ISM. Their effect in DGs was calculated by de Young & Heckman (ApJ 431, 598). A SB which produces about 100 SNe may remove the entire ISM content of a dex(7) Mo DG. The very low mass DGs may thus be extremely metal-poor.

Marlowe + (ApJ 438, 563) showed that in a sample of M_B>-18 DGs with SF there are giant expanding outflows, sometimes aligned with the galaxy minor axis. This is not seen in all objects, indicating a low duty fraction of the SB stage. In N1569 Heckman + (ApJ 448, 98) found that the SB created giant bubbles and extended H-alpha filaments, as well as X-ray emission. Similar cases are N5253 (Martin & Kennicutt ApJ 447, 171) and Ho IX (Miller ApJ 446, L75). Evidence for an expanding ISM bubble was presented by Tomita + (PASJ 46, 331) for N1569. ISM ejected from DGs may even be a source of X-ray emitting gas in clusters of galaxies (Trenton: Nature 372, 157). The super-bubbles could be responsible for QSO absorption lines (Shi ApJ 449, 141).

The formation of DGs by tidal interactions was studied by Hunsberger + (ApJ 462, 50). In the interacting pair IC2163+N2207 Elmegreen + (ApJ 453, 100) found large HI clouds, possibly forming into detached DGs. Theoretical aspects of the DGs dissolving into the accretor galaxy and leaving compact remains looking as globular clusters (GCs) were presented by Larson ('Formation of the galactic halo' p. 241). Bassino +

(ApJ 431, 1) showed that in tidal interactions between large galaxies and nucleated dEs the DG nucleus may survive and look like a GC. In well defined neighborhoods such as the M81 group, where tidal interactions and HI tails are observed, not all DGs show SF. Miller & Hodge (ApJ 427, 656) found that M81dA has almost no SF, while M81dB is bursting.

Henning (ApJ 450, 578) found very few objects in a blind search for HI clouds (37 detections among 7204 directions searched), none a low-mass, very low surface brightness object. The intergalactic space, even in regions devoid of luminous galaxies, contains HI clouds (Shull+ AJ 111, 72). A link between DGs and intergalactic HI clouds is in the finding of Taylor + (ApJS 99, 427) of HI companions to HII galaxies. Van Zee + (AJ 109, 990) found that the majority of their 79 BCDs studied from Arecibo had extended HI envelopes. Similar results were reported by Hoffman + (ApJS 105, 269) from mapping a large sample of late-type DGs. Szomoru + (AJ 11, 2141+2150) found large numbers of HI companions to IRAS-selected galaxies in voids; some appear to be DGs. In HII galaxies with HI companions, Taylor + (AJ 107, 971) showed that the SF takes place in regions with HI surface density higher than dex(21)/cm^2. While LSBs have flattened (HI) profiles, the HII galaxies have sharply peaked HI distributions.

A new class of DG was identified by Schombert + (AJ 110, 2067): dwarf spirals. They may be reside only in the field, as none were discovered in deep imaging studies of galaxy clusters. N2915 may be an extreme example of this class; it has HI spiral arms and a BCD core (Meurer+ AJ 111, 1551).

Bursting galaxies have long periods of quiescence. A single, intense SB may be followed by a steady decline as stars die off. Phillips & Driver (MNRAS 274, 832) think this possible; in a search for LSB galaxies Schwartzenberg + (MNRAS 275, 121) found space densities ten times higher than that of normal galaxies. However, Gallagher + (AJ 109, 2003) studied a sample of very faint galaxies in the southern skies from which they derived a flat luminosity function for galaxies with dex(8-9) solar masses of HI. Roukema & Peterson (A&AS 109, 511) found only a low space density of galaxies with -14>M(B)>-20, corresponding to 6% of the density of normal galaxies.

Leitherer & Heckman (ApJS 96, 9) published a grid of models to synthesize properties of SB galaxies; some results describe well BCDs and other SB DGs. Nath & Chiba (ApJ 454, 604) showed that DGs may enrich the intracluster medium with metals; this mechanism is relevant only for low metallicity clusters.

DGs may be relatives of very distant galaxies. McGaugh (Nature 367, 538) proposed that LSBs may be faded remains of high-z SB DGs; these may make up the blue component of the galaxy population and may be responsible for the Butcher-Oemler blue galaxies. Smail + (ApJ Lett. 449, L105) succeeded in modeling the population of very faint Keck galaxies (to R=27) with a majority of very faint blue galaxies, which are either DGs or sub-galactic units. A large population of late-type galaxies at high-z is indicated by the morphological mix of galaxies in deep HST images (Driver + ApJ 449, L21; Im + ApJ ApJ 445, L15); some may be DGs.

4. Magellanic Clouds
(Michael Feast)

There is now an electronic Magellanic Clouds Newsletter (eds. Y-H Chu & D.K. Bomans: MCnews@astro.uiuc.edu; http://www.astro.uiuc.edu/mcnews/MCnews.html. A complete listing of MC papers can be found in a special section of AA Abstracts. The following sections concentrate primarily on those aspects of MC research which relate to the MC as galaxies. Other studies (e.g. related to stellar evolution, the study of stellar atmospheres, peculiar stars, PN, HII regions, etc.) will, we hope, be discussed in the reports of other commissions. SN1987A has, however, been given fairly complete coverage.

The Cepheid extragalactic distance scale continues to be based on an adopted LMC modulus of 18.50. A recent calibration based on Cepheids in galactic open clusters gives a modulus slightly larger than this, 18.57 ± 0.10 (Feast ASP Conf. Ser. 83, 209, Laney & Stobie MN 266, 441) when referred to an equivalent Pleiades modulus of 5.62. An infrared Baade-Wesselink Cepheid scale gives an LMC modulus of 18.58 (Laney & Stobie ASP Conf. Ser. 83, 254). A start has been made in attempting to derive Baade-Wesselink moduli directly for MC Cepheids (Barnes + ApJ 405, L51, Gieren MN 265, 184, Gieren + ApJ 433, L73) and further work will be valuable especially if it can be extended to the infrared and so avoid problems which are known to affect optical Baade-Wesselink analyses. Bertelli + (ApJ 412, 160) derived moduli for the LMC clusters NGC 1866 and 2031 of 18.51 ± 0.21 and 18.32 ± 0.20 by requiring equality of the pulsational and evolutionary masses for their Cepheid members. Sebo & Wood (ApJ 449, 164) combine Cepheid observations with theory to obtain an LMC modulus of 18.60. Di Benedetto (ApJ 452, 195) discusses a Cepheid calibration referred to surface brightness estimates of non-variable giants and supergiants.

The LMC modulus based on RR Lyrae variables is still under discussion, but it has been suggested to be close to the Cepheid distance when statistical effects are taken into account (ASP Conf. Ser. 83, esp. Walker p. 198, Feast p. 209). On the other hand, Gould (ApJ 452, 189) derived an upper limit of 18.37 for the LMC modulus from a reanalysis of the SN1987A ring. This discrepancy has not been resolved (See also Crotts + ApJ 438, 724, who obtain a modulus of 18.6 ± 0.1 using earlier estimates of the ring size in light travel time and Plait + ApJ 439, 730). Eclipsing binaries may eventually yield an independent LMC modulus. An initial attempt (Bell + MN 265, 1047) gave 18.1 ± 0.3. Spectroscopic parallaxes of OB stars give moduli of 18.4 ± 0.1 (LMC) and 19.1 ± 0.3 according to Massey + (ApJ 438, 188). Valle & Livio (ApJ 452, 794) recalibrated novae as distance indicators using LMC and M31 data.

The overall structure of the MC was briefly reviewed (Feast IAU Sym. 164, 153). The large number of variable stars being discovered in the LMC in the microlensing surveys opens up the prospect of a much more detailed study of MC structure than was previously possible (see e.g. 12th IAP Coll. 1996 in press). The significance of LMC-LMC microlensing has been discussed by several workers (e.g. ApJ 461, 84 and references therein).

The proper motion of the LMC was measured and used to study the motion of the MC, the origin of the Magellanic Stream, and the mass of our Galaxy (Jones + AJ 107, 1333, Lin + ApJ 439, 652; see also Kroupa + MN 266, 412). Amongst studies related to the large scale structure of the MC are: Kennicutt + (AJ 109, 594, the large scale structure of ionized gas in MC), le Coarer + A&A 280, 365, H alpha emission distribution and velocity field of the SMC), Meyssonnier & Azzopardi (A&AS 102, 451, an H-alpha catalogue of emission line stars and small nebulae in the SMC), Magnier + (ApJ 464, 829, superbubble N44 in the LMC), Snowden & Petre (ApJ 436, L123, an X-ray image of the LMC from ROSAT), Elson + (PASP 106, 632, evidence of a metal poor, spheroidal component in the LMC), Filipovic + (A&AS 111, 311

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catalogue of continuum radio sources in LMC), Morgan & Hatzidimitriou A&AS 115, 539 catalogue of C stars in the outer parts of the SMC), Westerlund + (A&A 303, 107 JHK and spectra of faint C stars in the SMC), Dickey + (A&A 289, 357 survey of 21 cm absorption lines in the LMC), Mochizuki + (ApJ 430, L37 an LMC survey in the [CII] 158 μ line, Ellingson + (MN 269 1019) and Beasley + (ApJ 459, 600 methanol maser surveys which indicate a lower detection rate than expected from a comparison with galactic surveys).

The general features of the Magellanic system including the great depth of the SMC in the line of sight and the Magellanic Stream are reproduced in the numerical simulations of Gardiner + (MN 266, 567 and 278, 208). In contrast to this approach, a ram-pressure model is discussed by Moore & Davis (MN 270, 209). The dynamical evolution of the Magellanic system considered as a stable binary configuration is discussed by Heller & Rohlfs (A&A 291, 1994), including collision effects of a close LMC-SMC approach. Byrd + (AJ 107, 2055) suggest that the MC left the region of M31 about 10 Gyr ago. High velocity clouds in the halo of our galaxy may have been stripped from the MC (Lu+ ApJ 426, 563, Wolfire + ApJ 453, 673). Weinberg (ApJ 455, L31) suggests that the MC produce a wake in the halo of our galaxy which then produces the observed distortion of the galactic disk. Irwin + (ApJ 453, L21) suggest that the Pyxis object may be a detached globular cluster of the MC system. The chemical composition of two B-type stars between the two Clouds is similar to that of SMC stars and they imply significant current star formation in this region. Courte + (A&A 297, 338) find uv-bright stars in the bridge region. H-alpha emission has been detected from the Magellanic Stream; the heating of this gas by interaction with that of the halo of our Galaxy suggests that the latter is very extended (Weiner & Williams AJ 111, 1156). Absorption-line studies of Magellanic Stream gas rule out the possibility that it is primordial (Lu + ApJ 437, L119), whilst Meyer + (ApJ 437, L59) speculate that the low O/H ratio in Orion is due to recent infall of material from the Magellanic Stream.

A large amount of work continues to be devoted to SN1987A, particularly its ring system. The inner ring has been interpreted as a protostellar disk (McCray & Lin Nat. 369, 378); and the forthcoming (AD 1999 ± 3) impact of the envelope with the ring discussed (Luo + ApJ 430, 264). Gould (ApJ 425, 51) discussed the possible ellipticity of the inner ring, whilst Lundquist & Fransson (ApJ 464, 924) model its line emission. A new diameter of the inner ring was obtained (Jakobsen ApJ 435, L47). There does not seem yet any full understanding of the triple ring system. Lloyd + (MN 273, L19) invoke the effects of a low mass binary companion to explain the system. Meaburn + (A&A 299, L1) present evidence suggesting that the ring system formed 2-3 X 10^4 yr ago. Martin & Arnett (ApJ 447, 378) discuss in detail the interacting-wind model. Burderi & King (MN 276, 1141) suggest that the rings are parts of a shell brightened by interaction with relativistic beams from a newly-formed pulsar. HST data on the triple ring system are presented by Burrows + (ApJ 452, 680), various models are discussed but none found entirely satisfactory. Spectroscopic observations (Panagia + ApJ 459, L17) suggest that the material of the outer ring was ejected from the progenitor about 10^4 yr before the inner-ring material. The light echoes from SN1987A have been used to study the three-dimensional structure in the reflecting material (Spyromilio + MN 274, 256, Xu + ApJ 451, 806).

Liu & Dalgarno (ApJ 454, 472) estimate the temperature of the O-emitting region of the ejecta. Modelling of gamma-ray observations shows that the Ni^{56} is much more centrally condensed than in standard models (Burrows & van Riper ApJ 455, 215) and the effects of the nickel bubble instability were evaluated (Basko ApJ 425, 264). Flucuations in the [OI] line profiles have been used to deduce an oxygen mass (Chugai ApJ 428, L17), and the H-alpha asymmetry at the Bochum event discussed (Utrobin + A&A 295, 129). Li & McCray (ApJ 441, 821) model the excitation of the HeI lines.

Absolute fluxes for days 158-314 (Hanuschik + A&A 281, 737), near-IR spectra for days 939-1445 (Bautista + AJ 109, 729), and a catalog of IUE observations for days 1.6 to 1567 (Pun + ApJS 99, 223) were published as well as 843 MHz fluxes for the first 2750 days following outburst (Ball + ApJ 453, 864). The radio and optical positions of the SN are closely coincident (Reynolds + A&A 304, 116). The SN has been detected by ROSAT (Beuermann + A&A 281, L45, Gorenstein + ApJ 420, L25). Colgan + (ApJ 427, 874) present further evidence for the formation of dust in clumps. Brown & Bethe (ApJ 423, 659 and ApJ 445, L129) suggest that SN 1987A produced a low mass, about 1.5 M_o, black hole and that there may be many such in our Galaxy. The light curve does not show the expected effects of accretion of material onto a neutron star, supporting the view that the SN remnant is a black hole (Brown & Weingartner ApJ 436, 843). Initial ASCA results suggest that about half the SNRs produced in the LMC within the last 1500yr came from SNe Ia (Hughes + ApJ 444, L81).

The star cluster population is of key importance in understanding the structure and evolution of the MC. Reviews of some of these matters (including chemical composition) are in ASP Conf. Ser. 48 and IAU Symp. 164 (esp. Olszewski, Feast). Conflicting estimates of chemical abundances in young globular clusters continue to be published, and this remains an area of concern (e.g. some of the above reviews; Jasniewicz & The A&A 282, 717; Hilker + A&A 294, 648; Chiosi + A&A 293, 710; Meliani + A&A 290, 752 - note that the low metallicity of NGC 1818 found in this paper is not independent of the similar result of Richler + A&A 225, 351 - Banks + MN 274, 1225; Meliani + A&A 300, 349). In the case of cool supergiants, some of differences between these papers probably result from difficulties outlined earlier by Bessell (New Aspects of Magellanic Cloud Research, ed. Baschek + 1992, Springer, p. 321).

There also appears to be still uncertainty as to whether the oldest MC globular clusters are the same age as or younger than those in our Galaxy (e.g. above reviews; Zinn ASP Conf. Ser. 48, Testa + MN 275, 454). Triaxiality of MC clusters was studied by Han & Ryden (ApJ 433, 80) and Ryder (ApJ 461, 146). Banks + (MN 272, 821) advise caution in the interpretation of radial variations in ellipticity and position angle of MC clusters following model simulations.

Lequeux (A&A 287, 368) suggested that there might be large amounts of cold molecular hydrogen in the SMC. Continuum emission at 2mm is mainly thermal and associated with very cold dust in molecular clouds (Dall'Oglio + A&A 303, 737). Many molecular species have been detected in a mm survey of the LMC (Johansson + A&A 291, 89). Chu + (AJ 108, 1696) find no evidence that the LMC is uniformly surrounded by hot gas; hot gas is preferentially associated with large interstellar structures like superbubbles and supergiant shells, which may extend to large distances from the plane. Astro-2 observations have been used to deduce H_2 column densities and the far-uv extinction curve for the LMC, the latter indicating that large numbers of small grains are present (Clayton + ApJ 460, 313). The allowable range of parameters in modelling LMC interstellar dust observations is found to be quite wide (Maccioni & Perinotto A&A 284, 241). In the MC, in contrast to the MC, CO can exist only in the densest parts of clouds (Lequeux A&A 292, 371).

A determination of the relation of the C/O abundance ratio to O/H in HII regions in the MC and in seven dwarf irregular galaxies suggests that it may not be appropriate to combine abundances in irregular galaxies with those in spirals to study the evolution of chemical abundances (Garnett + ApJ 443, 64). Hill + (A&A 293, 347) find a mean [Fe/H] = -0.27 for nine FI distributed over the LMC. There is very little real spread. Meliani + (A&A 304, 347) obtained [Fe/H] = -0.71 for a group of red supergiants in the SMC from low-dispersion spectra. For four SMC B-type stars, Rolleston + (A&A 277, 10) find [M/H] about -0.8, [N/H] less than -1.1, [O/H] about -0.5, mild helium deficiency, and a suggestion of a range of abundances among these stars. Feast (MN 278, 11) suggested that Miras in the period range 100-300 days in the LMC have a metallicity near [M/H] = -0.6 on the basis of infrared colour - period relations.

5. LOCAL GROUP OF GALAXIES

Slobodan Ninković

During this triennium there was one meeting devoted to the Local Group of Galaxies (hereafter referred to as Local Group):

CTIO/ESO Workshop on the Local Group: Comparative and Global Properties

held in La Serena (Chile) from 25 to 28 January 1994. It covered various aspects of the Local-Group problematics such as: the Local Group and the properties of the ISM in Local-Group galaxies, young populations in Local-Group galaxies, old stellar populations in Local-Group galaxies, the dynamics of the Local Group and its members, the Local Group as a stepping stone to the Universe, etc. The contributions werre published in the proceedings (No 51 of ESO series).

During one of the regular Canary-Islands winter schools (that of December 1993) the Local Group was also among the topics. The observational approach was treated by Hodge (63.160.305), whereas the review concerning the Local-Group genesis was given by Lynden-Bell (63.160.306).

The membership was discussed several times. Van den Bergh (AJ 107, 1328) studied a set of 22 objects suspected as Local-Group members. He found for only three of them to be probable members obtaining in this way a total of 29 galaxies for which the membership in the Local Group seems reliably established. On the other hand Zabierowski (62.160.169) developed a membership criterion based on the galaxy redshifts. Finally, Ibata+ (MNRAS 277,781) communicated the discovery of a new Local Group galaxy in Sagittarius and nearer the Milky Way even than the Magellanic Clouds!

Byrd+ (58.160.220) by studying the dynamical past of the Local Group questioned the acceptability of the two-body approach usually used in studies of the Local Group. The motion of satellites of the Milky Way in the perturbing field of the Andromeda Nebula was studied by Chernin+ (Astron. Astroph. Trans. 7, 111). Some results were also obtained by Dolgachev and Kalinina (private communication) using the classical two-body approach.

The individual memebers of the Local Group were also subjects of various researches. The Andromeda Nebula was most frequently studied (the Magellanic Clouds are beyond the scope of the present report). The globular-cluster system of the Andromeda Nebula was studied for the purpose of establishing its properties, but also for the purpose of estimating the total mass of that galaxy. For instance Federici+ (AA 274, 87) and Ninkovi 'c (AphSpSc 215,1) reach similar conclusions concerning the Andromeda-Nebula total mass within the studied region. Reed+ (AJ 107,555) studied a sample of Andromeda-Nebula globular clusters in order to obtain their metallicities and metallicity distribution. The surface photometry for a sample of globular clusters in the Andromeda Nebula was studied by Fusi Pecci+ (AA 284,349). Viewed from the infrared the globular clusters of the Andromeda Nebula were studied by Cohen & Matthews (AJ 108,128). A general conclusion concerning all these studies of the globular-cluster system in the Andromeda Nebula is that, in spite of all unavoidable differences, its globular-cluster system is similar to that of the Milky Way, though more numerous; it is possible that the ratio of the total number of globular clusters follows the one of the total masses. The structure of its halo was studied by Pritchet and van den Bergh (AJ 107,1730). A model of the Andromeda Nebula with a massive corona was treated by Tenjes+ (AA 286,753). The dynamics of its inner parts was subject of Stark & Binney's study (ApJ 426,L31). The bulge was also studied by Sofue+ (PASJpn 46,1). The disc of the Andromeda Nebula (AB - supergiants) was studied by Herrero+ (AA 287,885). The ionised shells were subject in Hunter's paper (AJ 108,1658). In both cases another Local-Group galaxy (M33) was also studied. Observations of hot stars in the Andromeda Nebula were carried out by Bianchi+ (62.157.115) and by Bianchi+ (AA 292,213). The stellar population variation in the Andromeda-Nebula disc was studied by Morris+ (MNRAS 271,852). The microlensing by stars in the same disc was studied by Gould (ApJ 435,573). Based on the relationship with the rotation curve an estimate of the magnetic-field strength in the Andomeda Nebula was given (Vallée, ApJ 437,179) including also the corresponding estimate for the Milky Way. The CO emission from the massive molecular clouds of the Andromeda-Nebula inner disc was determined (Allen & Lequeux, 63.157.004). The possibility that the Andromeda Nebula has a strange double nucleus was communicated by King+ (63.157.027).

As far as known now, there are only three spiral galaxies in the Local Group (e. g. van den Bergh's list - AJ 107,1328), i. e. in addition to the Milky Way and the Andromeda Nebula, there is M33. There were, also, several studies devoted to this galaxy. Puerari (PASP 105,1290) studied its spiral structure. Buat+ (AA 281,666) investigated the distribution of the ultraviolet emission in the M33 disc. Constraints on the star-formation influence on the lowest ^{12}CO line ratios in M33 was studied by Thornley and Wilson (ApJ 421,458). A Pulsar search in M33 was undertaken by Fauci+ (61.157.194). The diffuse molecular clouds and the molecular interstellar medium from ^{13}CO observations in M33 were also studied (Wilson & Walker, ApJ 432,148). A map of M33 in the near infrared was obtained (Regan & Vogel, ApJ 434,536). The relativistic interstellar matter in M33 through the role of supernova remnants was investigated by Duric+ (ApJ 445,173). Finally, it seems that all the three - Mily Way, Andromeda Nebula and M33 - contain small and weak bars in their central regions.

A Workshop, devoted to dwarf galaxies, was held at St Michel (France) in early September 1993. As seen from the proceedings (63.012.009) the dwarf galaxies from the Local Group were also comprised. By the way, the sizes and positions for the Mailyan Dwarf Galaxy Catalog were revised (Madore+, PASP 106,63). On the other hand, according to van den Bergh (ApJ 428,617) a correlation is possible between the stellar content in a dwarf galaxy and its distance to the Milky Way (or Andromeda Nebula). Stellar populations in NGC 185 were subject in the paper of Lee+ (AJ 106,964). And III, suspected to be a companion of the Andromeda Nebula, was studied (CM diagram) by Armandroff+ (AJ 106,986). A tentative conclusion, according to which Leo I is the youngest Milky-Way dwarf spheroidal galaxy, was reached by Lee+ (AJ 106,1420). On the basis of the colour-magnitude diagram the distance of Andromeda II is estimated (König+, AJ 106,1819). The stellar populations of Leo I were used for the purpose of estimating the mass of the Milky Way (Lee+, 58.157.415). The stellar populations were also subject in the case of M32 (Hardy+, AJ 107,195) where the research was based on the spatially resolved spectrum of the galaxy. A comparison with well-known globular cluster 47 Tuc was important Rose's (AJ 107,206) study of the M32 integrated spectrum. For Leo I, sufficiently frequently studied during this period, was done the CCD photometry (Demers+, MNRAS 266,7). Black-hole models for the dark matter in Draco and Ursa Minor galaxies were extended (Strobel & Lake, ApJ 424,L83). Fornax, with its globular-cluster system, was also interesting for research in the given period (e. g. Demers+, AJ 108,1648). Sextans was studied dynamically (Hargreaves+, MNRAS 269,957). The same group also carried out a dynamical study for Ursa Minor (Hargreaves+, MNRAS 271,833). A statement appears that during the triennium we had a large number of communications concerning the Local-Group dwarfs, especially concerning the satellites of the two giants - Milky Way and Andromeda Nebula. Though it seems probable, it cannot be said that all the dwarfs surely contain the dark matter in significant quantities.

The nova frequenncy in the Local Group was estimated by Sharov (Pis'ma v Azh 19,387) by studying this phenomenon in the Andromeda Nebula, its companions and M33.

Briefly, it may be said that during this triennium there was a sufficiently large number of communications concerning the individual galaxies - (suspected or reliable) members of the Local Group, rather than concerning the structure, kinematics and dynamics of the Group, as a whole.

6. GALAXIES IN VOIDS
(G. T. Petrov)

The superclustering of galaxies and the presence of voids are now accepted as fact, a paradigm among workers on large-scale structure. Amongst the famous known voids are Coma, Hercules, Bootes and Perseus-Pisces.

The structure of superclusters, the material entities that make up the contiguous shell, was revue by Oort (Ann.Rev.A&AP. 21, 373). The last revue concerning voids was one of Rood (Ann.Rev.A&Ap. 26, 631).

There are two ways that an individual void can be studied observationally:

a) the structure and content of the contiguous shell of superclusters surrounding the void

b) the void can be probed with telescopic sensors in attempts to detect something within it

The latter had been chosed for the program of studying voids started in 1990, as a joint work between Max Plank Institute of Astronomy, Heidelberg, Germany and the Department of Astronomy of the Bulgarian Academy of Sciences. The main task of the program was to check the lack of galaxies in some VOIDS and to look for a dwarf galaxies within. The idea is to use the 2 - m telescope of the National Astronomical Observatory "ROZCHEN" with its large field of 1° x 1° and scale ca.13"/mm. The program list contains one comparison field - the well known cluster of galaxies A 1376 and about 20 voids. (Petrov & Kovachev, C.r.Acad.Bulg.Sci. 45, No.6). Using the exposure time ca. 3 hours we had hope to reach a limiting magnitude bigger than the POSS limit - i.e. to detect fainter objects. As an independent source we had used a POSS glass copy. All the plates (except one) have been measured using " GLAREX " XY - measuring machine of the MPIA, Heidelberg. The SAO stars were used as first standards taken with " OVERLAY " program, running on VAX. As secondary standards, SAO stars were measured in the 1° x 1° around the center of each void. Program " AMETRY " and 3-th order fit were used to determine the parameters of our plates and the coordinates of measured objects. As a result, the differences of the coordinates of the objects on the plates became 1 - 2 arcs.

Some qualitative evaluations have been made for the objects measured on the plates:

a) Diameters in conditional scale: 1 < 1.9", 1.9<2 <3.6", 3.6<3<5.7", 4 >5.7" and 5 >>5.7".

b) Brightness: B- Bright, N- Normal and L- Low brightness objects.

c) Morphology: R- Ring, L- Lenticular, Prolongate and I- Irregular. For the objects marked as " L " the position angle in degree has been added.

- *Astrometry and basic parameters for galaxies in voids*

Alltogether 19 plates covered 10 of the voids choosen were taken during the 1991 -1993 and 8 of them had been measured. Five POSS plates had been measered too as control plates. As a result more than 8300 galaxies were measured and classified. Only 73 of them are presentin the Huchra's CfA redshift catalogue (Kovachev+, AG

Abstr.Ser. 9, 46; Kovachev & Petrov, C.r.Acad.Bulg.Sci. 45, No.9; Strigachev & Petrov, C.r.Acad.Bulg.Sci. 48). For example, in the direction of the Hercules void, only 225 galaxies were measured on the blue POSS plate and 1728 galaxies on our plates. Similary, in the direction of the void 2320 + 1339 we had found 90 galaxies on the blue POSS plates and 225 on our plate (Petrov+, C.r. Acad.Sci.Bulg. 47, No.6). In all the fields the surface dencitie of the galaxies is several times highes compared to one after the Lick's counts (Shane, in „Galaxies and the Universe", 647).

- *Automatic selection and classification*

The void 0049+00 had been studied in two ways - manually, as described above, and using the MIDAS context INVENTORY. 2257 galaxies were measured and classified manually and 2304 were selected by INVENTORY. Simple cluster analisys, using coordinates and magnitudes, pointed out to existing of subsistems in this direction (Petrov+, in press).

- *Steps to the structure of the Hercules void*

Monte Carlo simulations of the coordinates of 1728 points and Kolmogoroff-Smirnoff test for the real and simulated coordinates shows the galaxies are randomly and uniformly distributed. Lee-function for the position angles of real galaxies and Monte Carlo simulation of their orientation gave us no evidence for preferable orientation (Petrov &Petrov, C.r.Acad.Bulg.Sci. 49).

- *Aperture photometry of galaies in a direction of the void 1312+35*

444 galaxies were measured in the direction of the void 1312+35. Aperture photometry for 82 of them were established. These are predominantly faint galaxies - max of the distribution is 19 mag. Simple cluster analisys for the magnitudes and diameters shows some evidences for substructures and gave us a tool to devide Low Surface Brightness Galaxies. The light distribution across the major axes of the galaxies split the profiles in tree groups - one with smooth profiles following the Vaucouleur's law, second - disk and bulge galaxies and third - composite nuclei or mergers (Petrov & Strigachev, C.r.Acad.Bulg.Sci. 46, No.7; Strigachev & Petrov, C.r.Acad.Bulg.Sci. 47; Petrov+, in press).

- *Surface photometry of galaxies in the direction of voids*

CCD frames in two colours, taken with 2.2 and 3.5-m telecsopes of the Calar Alto observatory, were used to make a detailed surface photometry - ca. 100 galaxies altogether. In fact this sample is a mixture of intrinsically bright and faint galaxies. The first shows mean characteristics of typical Freeman's disk and the latter - for Low Surface Brightness galaxies.

Ca. 40 % of the surface brightness profiles can be described by single exponential disk and 20 % show some peculiarities (Vennik+, A&ApS 117, 261; Kovachev+, C.r.Acad.Bulg.Sci. 47, No.6; Hopp+, A&ApS 109, 537).

Rem : All the data are available on request via E_mail: *petrovgt@bgearn.acad.bg*.

7. Magnetic Fields in Spiral Galaxies

Elly M. Berkhuijsen

Interstellar magnetic fields are revealed by polarized emission at optical and radio wavelengths. As scattering effects seriously limit the interpretation of measurements of optical polarization, most of our knowledge of magnetic fields in galaxies is obtained from observations of the linearly polarized synchrotron emission at cm wavelengths ($\lambda\lambda 2-50$ cm). Observations at 2 or more wavelengths allow a correction for Faraday rotation and the determination of the intrinsic polarization angle. Rotation measures yield the direction of the field along the line of sight.

All of the more than 20 moderately inclined galaxies observed so far have large-scale regular magnetic fields (Beck +, ARA&A 34, 153, Table 2). Regular magnetic fields are generally directed along the optical spiral arms either inwards or outwards. In M31 and IC 342 the regular field has an axisymmetric structure (ASS), whereas that in M81 has a bisymmetric structure (BSS). In M51 and NGC 6946 the regular field has a mixed structure (MSS). For most of the observed galaxies the global field structure is unclear. In IC 342 and NGC 6946 narrow "magnetic spiral arms" were detected in between optical spiral arms. Polarization observations of 12 edge-on galaxies (Beck+, Table 3) showed that regular magnetic fields are generally parallel to the galactic plane, with notable deviations in M82, NGC 891 and NGC 4631 where the field has vertical components in large parts of the disk.

Magnetic field strengths are calculated assuming equipartition between the energy densities of cosmic ray particles and magnetic fields. Mean equipartition strengths of the total field range from ≈ 4 μG in M33 (Buczilowski +, AA 241, 47) to ≈ 12 μG in NGC 6946 (Ehle +, AA 273, 45), depending on the star formation rate. In spiral arms the total field strength reaches higher values, i.e. ~7 μG in M31 (Berkhuijsen +, AA 279, 359), ~20 μG in NGC 6946 (Beck, AA 251, 15), and even more in M51 (Berkhuijsen +, AA 1997, in press). Total field strengths are proportional to about the square root of the volume density of the total gas (Berkhuijsen +, AA 279, 359; Niklas +, AA 1996, in press; Berkhuijsen, in Lesch +, Proc. 156 WE-Heraeus Seminar, Akademie Verlag, Berlin, in press) suggesting close coupling between magnetic fields and gas clouds.

At short wavelengths the percentage polarization is indicative for the ratio of regular to turbulent field strengths, which is typically ≈ 0.5 on scales of a few kpc. In 3-kpc wide rings around the centre in M51 this ratio increases from 0.3 at $R = 4.5$ kpc to 0.4 at $R = 13.5$ kpc, whereas the total magnetic field strength decreases from 21 μG to 9 μG (Berkhuijsen +, AA 1997, in press). The equipartition strength of the regular magnetic field is typically 50–60% of the total field strength.

Turbulent magnetic fields arise in star forming regions, SNRs, superbubbles, chimneys, and winds which also transport magnetic fields into the halo.

The existence of turbulence leads to the widely used dynamo theory to explain the origin and structure of the large-scale magnetic fields, but other theories also exist. However, none of the present theories is able to explain the close alignment of the magnetic field with the spiral arms or the existence of regular fields between material spiral arms.

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8. Integral Field Spectroscopy of Galaxies

(E. Mediavilla, and S. Arribas)

When spectroscopy of extended objects (such as galaxies) is required, the problem arises of how to record three variables (α,δ,λ) in a two-dimensional detector. Traditionally, this has been solved by sequential procedures, which use time for scanning a third variable. In particular, the *classical* technique of long-slit scans consists in recording a set of 2-D frames [e.g.(α,λ)] changing one angular variable (δ) with time. Similarly, Fabry-Perot interferometers record a set of 2-D images (α,δ), changing the wavelength coordinate (λ) with time. From a conceptual point of view the major disadvantage of these techniques is the sequentiality: different bits of information are recorded at different times, which implies different atmospheric and instrumental conditions.

In recent years new techniques have been developed in order to pack the three relevant dimensions (α,δ,λ) into the two spatial dimensions of the current detectors. These techniques, called generically Integral Field Spectroscopy (IFS), imply a geometrical transformation of the image at the telescope focal plane. This transformation can be done with: i) an array of microlenses (TIGER, Courtes et al, in Instrumentation for Ground Based Optical Astronomy, Ed. Robinson, p. 267), ii) optical fibers (SILFID/ARGUS, Vanderriest and Lemonier, in Instrumentation for Ground Based Optical Astronomy, Ed. Robinson, p. 304; HEXAFLEX, Arribas et al, ApJ, 369, 260; 2D-FIS, Garcia et al, SPIE Symp., 2198, 15), iii) mirrors acting as image slicers (3D, Genzel et al, IAU Coll. 159), and iv) a combination of microlenses and optical fibers (Afanasiev et al, Academ. Nauk. USSR, preprint 54). Approach i) allows a good spatial resolution, but presents some spectral restrictions. Conversely, in approach ii) the geometry of the fibers does not permit a full coverage of the object (an hexagonal lattice of fibers can cover only a 50% of the space), though it allows good spectral coverage and resolution, which basically depends on the spectrograph design. Perhaps the best approach from a conceptual point of view is iv) as it permits full spatial coverage, and presents no serious spectral restrictions, but in practice is difficult to carry out with intermediate and small telescopes of reduced focal plane scales. A common drawback of the different approaches of the IFS is the tiny field of view ($\sim 10'' \times 10''$) when compared, for instance, with Fabry-Perot interferometers.

The treatment of data in all the mentioned IFS instruments is basically the same: at the detector a set of spectra is recorded simultaneously each one corresponding to a region in the object. By software 2D images of any spectral feature related to the spectra (like continuum maps, line intensity maps, velocity fields, etc.) can be reconstructed. Although IFS has been applied to very different fields in Astrophysics, galaxies are perhaps the objects more extensively studied on the basis of this new technique. What follows does not pretend to be a complete review of all the studies of galaxies based on IFS, but just a representative sample.

Nuclei of galaxies: The results obtained with TIGER (Bacon et al, A&A, 281, 691) in the central region of M31, are very illustrative in this respect. Although the velocity field of the stars (derived from the stellar absorption lines) in M31 looks very regular, the 2D spectroscopy reveals the existence of offsets between the emission peak, the kinematic center, and the maximum of the velocity dispersion. This implies a displacement of the optical nucleus with respect to both the kinematic and galaxy bulge centers, which could be interpreted in terms of the oscillation of the nuclear stellar component around the galaxy's center. Other galaxies studied with IFS which show uncertain locations of the nucleus are NGC 3227, NGC 5728, and Mkn 463. In NGC 3227 the Seyfert 1 nucleus appear displaced with respect to the 2D velocity field of the ionized gas (Mediavilla & Arribas, Nature, 365, 420), implying the existence of an off-center supermasive black-hole. In NGC 5728 Pecontal et al (A&A, 232, 331) suggested the presence of an hidden Seyfert nuclei from observations with TIGER. This galaxy was also observed using HEXAFLEX by Arribas & Mediavilla (ApJ, 410, 552) which, on basis to 2D kinematic studies, located the hidden Seyfert nucleus in a position posteriourly confirmed by high resolution images from the HST. Finally, using SILFID, Vanderriest & Chatzichristou (A&A, 298, 34) have mapped the kinematics and ionization structure of the gas in the double nucleus galaxy Mrk 463. They identify a Seyfert nucleus and a lower activity (Seyfert-Liner) nucleus.

Active galaxies: The presence of strong emission lines and the intrinsic interest of these objects have motivated IFS studies of many of them. Velocity fields for the ionized gas have been obtained with different systems in several active galaxies (e.g. NGC 4151: Afanasiev & Shapovalova, in Mass-Transfer Induced Activity in Galaxies, Ed. Shoslman; NGC 1068: Arribas et al, ApJ, 463, 509; NGC1275: Ferruit & Pecontal, A&A, 288, 65). The IFS is very suited to analyze the emission line profiles observed in the circumnuclear region which show substructure likely produced by the integration in the line of sight of several different gaseous systems. In this respect, Arribas et al (ApJ, 463, 509) have attempted a kinematic deprojection of the different gaseous subsystems present in the circumnuclear region of NGC 1068, founding evidences for a biconical structure of ionization. A similar line-emission analysis based on IFS has been performed by Ferruit & Pecontal (A&A, 288, 65) in the famous active galaxy NGC 1275. They found and study several distinct components (broad, narrow nuclear, extended systemic, high velocity...) discussing the nature and origin of the different gaseous subsystems. The IFS studies of AGNs have not been restricted to optical wavelengths. Observations in the near infrared have been performed using the imaging slicer 3D. The infrared studies (Tacconi et al, VA, 40, 23) are specially relevant for they offer 2D information of regions close to the active nuclei which are obscured in the optical (e.g. Kroker et al, ApJ, 463, L55: IRAS FSC10214+4724; Genzel et al, ApJ, 444. 129: NGC7469).

Interacting galaxies and QSOs: These objects are very interesting in order to study the early history of galaxies, the galaxy evolution, and the role of galaxy interaction in the origin of activity. Haddad and Vanderriest (A&A, 245, 423) used SILFID to observe several interacting quasar-galaxy systems, analyzing the relationship between them from the systemic velocities and the existence of diffuse regions of ionized gas. The interaction of the two starburst galaxies PB6378 and 9261 was studied using the same instrument by Vanderriest & Reboul (A&A, 251, 43). The rather chaotic dynamics of the ionized gas around QSOs has been analyzed by Durret et al (A&A, 291, 392) who derived the velocity fields of the gas using TIGER. From observations with the same instrument, Petitjean et al (Nature, 380, 411) have very recently reported the presence of emission lines in the gas around the high redshift QSO BR1202-0725.

Regarding the future, some new instruments for IFS (like OASIS or INTEGRAL) are now being built. They include relevant improvements concerning the sensitivity, the enlargement of the field of view and the spatial sampling. It is interesting to comment that there are also projects in progress for building IFS instruments based in fibers and microlenses for some of the future large telescopes, like FUEGOS (Félenbock et al, SPIE Symp., 2198, 115) for the VLT-3 and IFU (Allintong-Smith et al, in Scientific and Engineering Frontiers for 8-10 m. Telescopes, Tokyo) for GEMINI.

9. AGN Variability (Mostly IR)

I.S. Glass

The observed infrared, optical and UV variations of AGNs continue to provide information about the spatial scales of circumnuclear material unobtainable by other methods. The following results mostly pertain to the infrared.

The IR flux from the archtypical Seyfert 2 NGC1068 appears to have increased steadily over 18 yr, amounting to a doubling at L (Glass MNRAS 276, L65).

NGC4593 has been the subject of a 2-yr monitoring program (Santos Lleo+, MNRAS 270, 580; 274, 1) from x-ray to IR. Good agreement was found between the values for the underlying galaxy contribution to the infrared fluxes as determined by the Choloniewski method and by optical profile fitting. The implied 2-folding time of a decrease observed in the infrared flux was 37 +/- 12 d. The IR and UV variations were found to be decoupled for any lag shorter than 8 d, but the sampling was insufficient to determine a definite lag. A one-season study of NGC3783 was reported by Stirpe+ (ApJ 425, 609). The UV continuum during this period only varied with low-amplitude on time scales of order 20 d; the effects at JHKL appear to have been washed out by the long time taken for the infrared response (~85 d; Glass MNRAS 256, 23p). In Mkn 744 an outburst at U, followed by a delayed (by 32 +/- 7 d) and spread out response at K', has been observed by Nelson (ApJ 465, L87). NGC 4051 (Salvati+, A&A 274, 174), during a 2-season monitoring program, observed a 0.5 mag K-band flare which did not appear to be the response to anything similar in the UV cnm light curve. Combining sporadic K measurements from various sources in the literature with more regular U observations by Lyutyi, Oknyanskii (A. Letts 18, 416) has found the K emission of NGC4151 to be delayed by 18 +/- 6 d. Short-term (~1 d) variations in the near-IR from several highly x-ray variable Seyferts were ruled out by Hunt+ (A&A 292, 67). No micro-variations (short-term, low-amplitude) were seen in the near-IR in NGC7469 by Dultzin-Hacyan+ (Rev Mex A Ap 25, 143).

The F9 data of Clavel+ (ApJ 337, 236) have been modelled in detail by Barvainis (ApJ 400, 502). The emission is shown to come from an optically thin region.

A sample of 16 blazars has been observed by Kitchfield+ (MNRAS 270, 341) over 8 yr at JHKL. The blazar OJ 287 has been observed extensively and is the main subject of "Workshop on Two Yrs of Intensive Monitoring of OJ287 & 3C66A", ed Takalo, Tuorla Obsy, 1996. This object shows an outburst about every 12 yr. Kidger+ (A&A 282, 369) show that it varies in the IR on time scales as short as 1 hr. Kidger+ (A&AS 113, 431) further point out that its SED does not change during outbursts, but that it alters slowly on a time scale of yrs. Hagen-Thorn+ (A&A 295, 319) show, using Choloniewski's method, that its spectrum remains constant except at highest flux levels, where L may show the effect of synchrotron self-absorption. Hagen-Thorn+ also show that, separately at BVR and JHK, the SEDs of 3C345 remain constant for years or more, irrespective of flux level, but do change over longer times.

The applicability of Choloniewski's method has been questioned by Doroshenko & Lyutyi (A Letts 20, 606). Cross-correlation methodology is discussed by White & Peterson (PASP 106, 879) as well as in the conferences below.

Several conference volumes with germane material have been published in the triennium: Nature of Compact Objects in AGNs ed Robinson & Terlevich, CUP 1994; Active Galactic Nuclei across the EM Spectrum (IAU S159), ed Courvoisier & Blecha, Kluwer 1994; *Reverberation Mapping of the BL Region in AGNs*, ed Gondhalekar+, ASP 1994; Proc Oxford Torus Wshop, ed Ward & O'Brien, Vistas 40,1.

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10. Counter-rotation in galaxies.
(Giuseppe Galletta)

Recent works on some disk galaxies emphasized the problem of the gas/star counterrotation, a feature first observed in elliptical galaxies. The systems with counterrotation are generally morphologically normal, but possess a quantity of gas or stars circulating with a spin opposite to that of the most part of the stars. The majority of the authors that studied the phenomenon attribute this peculiarity to the accretion of matter from outside the galaxy. A total of 46 cases of counterrotation are known at present (Galletta ASP Conf 91 429). As described in the following, different kind of counterrotations have been detected.

The last three years were characterized by the discovery of many new interesting cases. The S0 NGC 7332 (Fisher + AJ 107 160) has a counter-rotating gas disks and presents a variety of peculiarities: asymmetric motions, a boxy bulge, a wavy shape in stellar rotation along the bar. The S0 NGC 4546 was observed in CO (Sage & Galletta AJ 108 1633) revealing that cold gas is moving retrograde with respect to the stellar rotation, and in agreement with the previous studies of the ionized (HII) and cool (HI) gas. A new case of elliptical galaxy, NGC 5354 (Bettoni + 1995 ASP Conf Ser 70) was found inside a compact group of galaxies.

But the true novelty was the finding of counterrotation in spiral galaxies, richer than S0s in native gas. The abundance of this gas should prevent, in principle, the survival of accreted matter. Despite this, an outer ring in counterrotation was found in the Spiral NGC 4826, (van Driel & Buta PASJ 45 L47, Rubin AJ 107 173, Rix + ApJ 438 155) and even an extended disks, co-spatial with the stellar disk, in NGC 3626 (Ciri+ 1995). More complex cases are NGC 3593 (Bertola + ApJ 458 67), NGC 4138 (Jore + BAAS 18710905J), NGC 4550 (Rubin + ApJ 394 L9, Rix + ApJ 400 L5), NGC 7217 (Merrifield & Kuijken ApJ 432 575), which present also stars in counterrotation.

This latter is another feature only recently found in disk galaxies, though known since some years for elliptical galaxies. Inside these systems, part of the stars are moving in the opposite direction with respect to the remaining ones. Its analysis has been possible thanks to the development of numerical techniques for the analysis of the stellar spectra. Inside NGC 4550 (Rubin + 1992 ApJ 394 L9) one half of the stars counterrotates with respect to the other half. A gas disk, coincident with one of the two stellar disks, is also observed. This is the only known case of S0 of this kind. However, differently than for E and S0s, stellar counterrotation has been discovered with more frequency in Spiral galaxies: such a case is represented by NGC 7217 (Merrifield & Kuijken ApJ 432 575), which has about 20-30% of the stars in counterrotation. The gas present is rotating according to the majority of stars. An opposite situation is present in NGC 4138 (Jore + BAAS 18710905J): the totality of the gas present (HI) corotates with the 20% of the stars, with spins opposite to that of most part of stars. This situation is visible also in NGC 3593 (Bertola + ApJ 458 67). An additional case is the bulge of NGC 7331, that rotates retrograde to its disk (Prada + ApJ 463 L9).

If stellar counterrotation is present in different morphological type of galaxies, there is another feature suggesting retrograde stellar motion that only happens in barred galaxies. This is the "waving pattern" (Bettoni AJ 97 79) of the rotation curve found in many S0s and of the barred spiral NGC 6701 (Marquez, ASP Conf 91 108). This effect has been explained with self-consistent models of barred galaxies (Wozniak & Pfenniger ASP Conf 91 445). In these system, the waving pattern is a consequence of the presence of a quantity of stars in retrograde motion that may range from 14 to 30% of the total.

To complete the mosaic of known type of counterrotation, gas in retrograde motion with respect to other gas has been also observed in NGC 4826 (Braun + Nature 360 442) by means of HI emission. Differently from the above types of counterrotation (gas vs. stars and stars vs.

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stars) the two structures in opposite motions are never co-spatial. In NGC 4826 a reversal of the sense of rotation is observed in the central 2 kpc of the galaxy, with gas external to this radius moving opposite to stars. The alignment between two disks has been estimated to be $\leq 45°$. Two inclined gas disks have been detected in the E galaxy NGC 1052 (Plana + ASP Conf 71 133).

The origin of counterrotation has been linked with mergers of small galaxies or continuous gas accretion. The idea that these galaxies are connected with minor-axis dust-lane ellipticals and polar ring S0s was presented also (Sage & Galletta ApJ 419 544, Galletta ASP Conf 91 429). In comparison with the many models existing in the literature to explain the origin and evolution of polar rings, very few has been done about counterrotation. The papers on the subject are generally devoted to a single object, as in the case of NGC 4550 (Rix + ApJ 400 L5) for which a later, adiabatic addition of gas is deduced. According to the authors, large quantities of gas may be absorbed without to heat dramatically the disk, and then turned in stars. This mechanism should prevent the instabilities present in the case of stellar merging, that on the contrary would destroy the disk of the galaxy receiving the matter from the environment. Discussing NGC 7217 it has been suggested (Merrifield + ApJ 432 575) that the galaxies with stellar counterrotation all would have faint or not defined spiral structure. Counterrotation in this case should be the mechanism that may remove the gravitational instabilities that generate the spiral arms in normal galaxies. A discussion of the two stream instability, that apply in the case of counterrotation, predict the collapse to the center of the accreted gas, with consequent transformation in stars. When stars are formed, under particular conditions (Sellwood + ApJ 425 530) two stable and co-spatial stellar disk in counterrotation can be produced.

The high quantity of mass found in counterrotation (Ciri + Nature 375 661, Galletta 1996 ASP 91 449), as much as 10^9 $M_\odot$ for gas and up to 10^{10} $M_\odot$ for stars, suggests that in these cases the origin of the matter cannot be due to the acquisition and disruption of a small satellite but to a slow infall of large quantities of matter. An alternative may be the stripping of gas during a close encounter with a big disk galaxy, happened quite far in the past.

11. Astronomy in FSU
(A.V. Zasov)

In general, astronomical research in FSU has been seriously undermined as a result of sharp shortage of financial support and the loss of the Central Asian Observatories by Russia.

A. OBSERVATIONS

CCD photometry of the brightest stars in two nearby dwarf galaxies, NGC 1569 and UGCA 92, was carried out by Karachentsev + (PAZh 20, 104). Photometric distance moduli are found to be 26.33 and 26.72. The distance was also estimated from photometric data for the Magellanic type galaxy NGC 1156 (A&A 310, 722).

Low brightness dwarfs in the core of the Coma cluster were studied by Karachentsev (A&A 296, 633).

Multicolor surface photometry of galaxies and calculations of models of mass distribution based on the fitting of rotation curves were accomplished by Hagen-Thorn + (AZh 73, 36) for the M82-type galaxy NGC 2748 and Gusev + (AZh 73, 357) for spiral galaxies NGC 1620, 7292, and 7743.

Artyikh + (PAZh 21, 723) gave results of observations of 29 high- and ultra-luminious far infrared galaxies at 102 MHz. Interplanetary scintillation was used to separate point nuclear sources from the rest of the galaxy. In most cases, the expected scintillating sources were not detected, evidently due to significant free-free absorption of radio fluxes at low frequency.

Sil'chenko (AZh 71, 706) continued to search for chemically decoupled nuclei in galaxies. A list of 34 candidate galaxies seen on the northern sky, which may possess chemically decoupled nuclei, is compiled by using multi-aperture photoelectric photometry from the catalog of Longo and de Vaucouleurs. These galaxies have red nuclei distinguished from the bulges by their color. Spectral observations confirmed frequent occurrence of nuclei distinguished by their abundance from the rest of the galaxy. The famous elliptical liner, NGC 1052, has appeared to have a resolved, chemically decoupled nucleus with a radius of 3-4"; the ionized gas inside this radius rotates together with the stars, but beyond it, gas moves perpendicularly to the stars (Sil'chenko PAZh 21, 323). A chemically decoupled nucleus is found in the Sab galaxy, NGC 4826, known for its counter-rotating outer gaseous disk (Sil'chenko PAZh 22, 124). Also chemically decoupled nuclei are discovered in NGC 2685 and NGC 2841. The former is a well-known polar ring galaxy and the latter a quite regular spiral, but both demonstrate nuclear gas rotation perpendicular to that of the stellar populations. Perhaps chemically decoupled nuclei may be related to the phenomenon of dynamically decoupled gas, both being the result of interaction in the past history of a galaxy.

Zasov + (A&AS in press) have found an unusual ring-like zone of radially expanding ionized gas in the inner galaxy at a radius of 1.8 kpc in the giant spiral NGC 6181 by using observations of the two-dimensional velocity field of this galaxy made with a scanning Fabry-Perot interferometer. The radial velocity reaches nearly 100 km/s and probably related to the inner Lindblad resonance.

Hagen-Thorn + (A&A 290, 693, A&A 291, 57) continued photometric and spectral investigations of polar-ring galaxies. It has been proven that stellar disks of of polar-ring galaxies are thicker than those of normal galaxies of similar types, evidently due to interaction events (A&AS 116, 417). The lenticular galaxy IC 1689 was found to possess an inner polar ring, with a radius of only 5" (2 kpc), which rotates in a plane perpendicular to the global disk of the galaxy (A&A 303, 398, A&A in press).

Lipovetsky + (ApJ 435, 647) continued to study blue compact dwarf galaxies. The new estimate of the primordial helium abundance is obtained, $Y_p = 0.241 \pm .003$.

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By considering a ratio of N/O in 30 BCDGs, a conclusion is reached about the primary nitrogen yield. The iron abundance is determined in 7 BCDG; a mean ratio of [O/H] = + 0.34 is found (ApJ 445, 108). For 40 BCDGs, full dynamical masses are estimated by using extended HI rotation curves; a ratio of dark matter to luminous matter varies from less than 0.5 to greater than 10, which suggests the existence of at least two mechanisms for BCDG formation. A new candidate for a galaxy in formation is discovered: SBS 0335-052 is probably experiencing its first burst of star formation, because there are no absorption lines in its integrated spectrum at all (ApJ, submitted).

B. THEORY AND STATISTICS

Pilyigin (AZh 71, 825) has proposed numerical and analytical models of chemical evolution of irregular galaxies that include the effects of non-selective heavy element losses due to an enriched galactic wind. An ordinary wind diminishes galactic mass, whereas an enriched one changes the relative abundance of heavy elements in the interstellar medium. Application of this approach to the evaluation of the primordial helium abundance led to $Y_p = 0.224$ (AZh 71, 833).

A test for determination of the nature of the generation of spiral density waves in galaxies (gravitational vs. hydrodynamical mechanism) was proposed by Lyakhovich + (AZh 73, 24). It is based on recent results of modeling and numerical experiments which have revealed the generation of anti-cyclonic vortices simultaneously with spiral density waves. The location of vortices (inside or between spiral arms) together with the observed shape of the rotation curve may serve as a promising test for different theoretical models of spirals in gaseous disks. In particular, in marginally gravitationally stable disks, vortices must be located between spiral arms.

Theoretical models of slowly rotating bars in early type galaxies were considered by Polyachenko & Polyacheno (PAZh 22, 337). It is shown that the conditions for the formation of a slow bar are significantly relaxed if the disk rotates inside of a massive halo, as often occurs in early type spiral galaxies. This implies destabilizing action of the slowly rotating spherical component on the development of the mode that forms slow bars, while the presence of a halo is known to be one of the most stabilizing factors for the formation of a fast bar. The role of bending instabilities was also discussed.

Analysis of total luminosities of spiral galaxies in the FIR range and in the H-alpha line (from published data) and their relations to star formation rate (SFR) was carried out by Zasov (PAZh 21, 730). The ratio of these luminosities changes along the (B-V) color sequence of galaxies, probably due to variation of the upper limit to stellar masses. The best agreement with evolutionary model with Salpeter IMF occurs for SFR = 2.5×10^{-10} $L(FIR)/L_o$ (M_o/yr). It was also shown that for most of the galaxies considered, a present gas content is much lower than one can expect in the case of constant efficiency of star formation (SFR over total gas mass) during their histories.

Gorbatsky + (A&A 288, 942) continued to devlope models of gaseous subsystems in galaxies; an evolution of giant molecular cloud ensembles in disk galaxies and thermal instability in haloes of cD galaxies were considered.

Statistical analysis of the distribution of observed (apparent) and real (deprojected) axis ratios, a/b, for edge-on galaxies was presented by Kudrya + (PAZh 20, 13). A sample of about 4500 flat galaxies used by the authors shows an exponentially declining distribution of axis ratios. The flattest galaxies have real axis ratios up to 26.

12. The Active Galactic Nuclei in Crimea.

V.Pronik

The analysis of the profile shape variability of $H\alpha$ line in NGC 4151 have been carried out by Sergeev S.G.(61.158.064). During three years of monitoring (Feb 1988 – Mar 1991) the response of the total flux of $H\alpha$ line to continuum changes was near linear and average profile shape was not changed more than by 5%. The asymmetry in the wings delay relative to the line center does not indicate pure circular or irregular motion but indicates an existence of component moving outside.

Malkov Yu.F.(58.158.237) have proposed a scheme of gas distribution and motion in AGNs, which is important to understand the various characteristics of these objects: the gas falling onto nucleus, the morphology and sizes of emitting regions, the formation of gaseous clouds, the direction of cloud motions, typical velocities and densities of the clouds in BLR etc.

Sergeev S.G., Malkov Yu.F., Chuvaev K.K. & Pronik V.I. (63.158.015) have presented the evidence of multi–component structure of the BLR in NGC 4151 and NGC 5548. It's shown that the profile variations can not be explained in the terms of light travel– time effects. The assumption of the presence of one non–variable and two variable components with different but constant profile shape is quite sufficient to fit any observed $H\alpha$ and $H\beta$ profiles in NGC 4151 or NGC 5548 during several years.

The behavior of broad hydrogen lines in spectra of NGC 7469 in 1972–1990 have been investigated by Doroshenko V.T., Sergeev S.G.& Chuvaev K.K. (61.158.065). The asymmetry of profiles of $H\alpha$ and $H\beta$ is variable but does not correlate with nucleus brightness. The FWHM of broad components increases from $H\alpha$ to $H\gamma$. Their intensities vary with a delay of about 28 days relative to the continuum changes. The Balmer decrement for broad components is much flatter than narrow ones.

The evidence of [O III] line flux variations about 25–100% during 4–9 years for 11 nearest quasars have been revealed by Pronik I.(61.159.096) using an observational data obtained by W.Zheng et al. The correlations $\lg L([\mathrm{O\,III}])$–$\lg L(H\beta)$, plotted for every of eleven objects, form three separate sequences.

The light curves of NGC 1275 nucleus in continuum and emission lines $H\beta$ and $[\mathrm{O\,III}]\lambda(4959+5007)$ for time interval 1982–1987 have been published by Merkulova N., Metik L. & Pronik I.(63.158.146). The relations F(cont)–F($H\beta$) and F($H\beta$)–F([O III]) are revealed.

Merkulova N.I. & Metik L.P.(61.158.350; 63.158.154) reported the increasing of the NGC 4151 nucleus brightness in 1989–1991 in UBVRI bands with the amplitude in U band about $1^m.4$ and one–third as large in I band. Color indices followed the variations on the light curve and indicated the common tendency of galaxy to become bluer with brightening. Complicated and unsynchronous changes of brightness and color indices both in ultraviolet and red spectral regions permit to suppose two variable sources in the NGC 1275 nucleus. Rapid (15–30 min) flares on its light curves within one night are discovered.

Procof'eva V.,Pronik I. & Sharipova L.(Astron.Astrophys.Transaction, 8, 285) have performed BVR–photometry of faint compact objects located in the neighborhood of nuclei of Seyfert galaxies NGC 1275, NGC 7469, Mkn 290, Mrn 298, 3C 120 and 3C 390.3. Obtained colour indexes permit to confirm that these compact objects have extragalactic nature and appear to be interacting with the nuclei of host galaxies.

The results of Space observation of galaxies obtained by Merkulova N., Metik L., Pronik I. & Pronik V. are in "Astrophysical Investigations with the Space Station ASTRON", Moscow, Nauka, 263–295, 1994. The evidences of variability of UV fluxes of two normal galaxies nuclei M 33, NGC 5236 and Mrk 573 are given. The test for study of the stellar population using the UV energy distribution is proposed.

In series of papers Efimov Yu.S. & Shakhovskoy N.M. (57.158.212; 58.158.046; 62.158.080; 62.158.081; 62.158.082) have published the results of the long-term international program of the monitoring of blazars OJ 287, 3C 66Å and S5 0716+71. The most important results were obtained for blazar OJ 287. The cyclic variations of position angle of polarization plane were detected firstly during its great outburst 1994–1995, indicating the continuous rotation of the polarization plane of emission with the period of about 35 days. This detection supports the two-component model containing the beamed jet with general helical magnetic field and moving shocks or "clumps" of rotating relativistic electrons. During two months the degree of polarization of S5 0716+71 decreased from 16% to 4%, simultaneously the large rotation of the position angle of polarization was observed.

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13. Astronomy at Abastumani Astrophysical Observatory, Republic of Georgia
(T. Borchkhadze)

A new model for accretion flows onto a black hole has been suggested (Krishan Machabely & Melikidze, (ApJ submitted). This model provides the high-frequency radiation from AGNs. The possibility of plasma retention by magnetic fields is being discussed. It is shown that, due to development of the flute instability, the region where magnetic and kinetic pressures are equal can be located farther from the source than the last Kepplerian orbit. The flute instability leads to the formation of magnetic flux tudes in which the observed X-ray emission is generated. The sequence of plasma processes leads to converting of the flow energy gained by the protons in the gravitational field into energy of electrons in a direction transverse to the magnetic field. The synchrotron emission then could provide the X-ray emission.

The formation of large scale structure (LSS) of the universe is investigated in models with mixed dark matter and non-zero cosmological constant (Kahniashvili & Lukash J. Georgian Phys. Soc. 2, 1995, Kahniashvili + Helv. Phys. Acta in press, Kahniashvili + in Proc. VIII Rencontres de Blois, in press). There was obtained the power spectra of inhomogeneities and discussed the LSS parameters' dependence on the model parameters (amount in total density of hot particles, massless collisionless particles species number, cosmological constant value, Hubble constant). Using normalization to COBE data of power spectra, some characteristic parameters of LSS (Correlation functions of galaxies and clusters, bulk motion velocities, bias parameters, microwave quadrupole) were obtained and compared with observed values.

A PC version of the Abastumani Merged Catalogue of Galaxies, ABMCG, containing detailed information for 35,527 objects (about 30 parameters for each galaxy) has been completed (Kogoshvili & Borchakhadze, Bull. Abastum. Astrophys. Obs, 73 and to be published). Access to every object can be obtained with five cross-identifiers, NGC, IC, MCG, UCG, and Mrk numbers. ABMCG is being systematically updated as new data are publised.

Flat spiral, edge-on galaxies, F, with axis ratios b/a less than 0.15 were singled out from ABMCG. The estimation of Tully-Fisher relation between linear diameters and 21 cm line widths for F galaxies revealed a tight correlation. The structure of the Virgo Cluster containing relatively bright galaxies was analyzed on the basis of criteria suggested by Anosova and based on the apparent separation of possible physical components and their radial velocity proximity. ABMCG was used for resulting calculations. Three pronounced subclusters of bright galaxies and several small concentrations emerge clearly from the area covered by the cluster. Mean values of color excesses were estimated for spiral galaxies in two main galaxy subclusters. Statistically significant differences in colors were found to be $+0.068 \pm 0.025$ m.

14. New AGNs Discovered in China
(Zou Z. and Li Q.)

We report on the preliminary results of several ongoing programs using 2.16 m telescope at Xinglong Station of Beijing Astronomical Observatory, which lead to the discoverey of about 150 new AGNs in the past two years, including QSOs, BL Lac objects, and Seyfert galaxies.

A. AGNS SELECTED FROM ROSAT SOURCES

At Beijing Astronomical Observatory, we have started a program to identify ROSAT X-ray sources using the 2.16m telescope. As the first step, a new quasar with a redshift of 0.32 and V = 17.91 in a $2^{o}X2^{o}$ area of RASS was discovered by Zhao + (Acta Astrophys. Sin. 14, 385). More recently, two new quasars and several Seyfert galaxies were also identified in the same area by Zhao + (IAU Colloq. 159).

After the release of the catalog of ROSAT PSPC pointed sources, we selected a bright sample from it with the following criteria: 1) count rate at least 0.05 s^{-1}, 2) positive declination, 3) more than 20^{o} from the galactic plane, 4) size less than 6", 5) not a known AGN, CV, WD, or XRB. The optically bright subsample with V = 13.5-16.5, estimated from the CD-ROM of the Digitized Sky Survey, includes 150 objects. Slit spectra of 96 of them have been taken with the 2.16 m telescope at a resolution of 4.7 A/pixel and wavelength coverage of 3800-8000 A. Classification of the sepctra shows that the are 5 quasars and 11 Seyfert galaxies. The quasar redshifts are 0.081, 0.143, 0.165, 0.312, and 0.760 and the V magnitudes are 15.4, 15.6, 16.0, 16.4, and 15.7 (Wei + IAU Colloq. 159). The optically faint sample with V = 16.5-18.5 estimated from DSS include about 350 sources. The spectra of 62 have been taken so far, leading to the identification of 23 QSOs, 13 Seyferts, and 10 objects that are QSOs or Seyferts.

Another sample was selected from the cross-correlation of ROSAT PSPC and 5G radio sources with the following criteria: 1) declination above -10^{o}, 2) more than 20^{o} from the galactic plane, 3) size less than 6", and 4) not cataloged as an AGN by Veron-Cetty and Veron and not a star brighter than V = 13.5, 5) apparent counterpart visible on DSS. There are 160 objects, of which 56 have been observed, including 24 quasars, 3 BL Lac candidates, and 2 Seyferts. The data on 8 quasars with redshifts of 0.333 to 1.091 were published by Wei + (Acta Astrophys. Sin. 15, 390). It is worth mentioning that the ROSAT source 1RXP J160338+1554 was identified as a LINER with unusually high luminosity by Wu (1996 PhD thesis, Beijing Astronomical Observatory). In the same sample, Xie + (Acta Astrophys. Sin. 16, 327) found 7 BL Lac objects and a quasar.

B. ACTIVE GALAXIES SELECTED FROM IRAS EGCAT

Following the criteria by de Grijip (Nat. 314, 240), a sample was selected from the IRAS EGCAT to search for new Seyfert galaxies, based on 25-60 μ spectral index. Of the 45 sources observed so far, 23 are new Seyferts, including one Sy 1, 13 Sy 2's, and nine Sy 3's. The first part of the result has been reported by Gu + (ApSS 229, 317).

Apart from the Seyfert galaxies, most of the objects are starburst galaxies, for example F06296+5743, a very massive starburst with strong Balmer absorption lines and a blue continuum (Huang + A&A 311, 21) and F07164+5301, an extreme starburst with WR features (Huang + ApSS 235, 109).

C. AGNs DISCOVERED IN A SAMPLE OF VERY LUMINOUS IRAS GALAXIES

Wu + (IAU Colloq. 159) selected a sample of very luminous IRAS galaxies (VLIRGs) from the 1.96 Jy catalog of Strauss + (ApJS 83, 29) with the following properties: 1) positive declination, 2) infrared luminosity in excess of $10^{11.5}$ L_{o} for H = 50, q = ½, 3) Zwicky magnitude brighter than 15.5. Spectra of 73 were taken with resolution of about 10 A (2 pixels) and wavelength covereage of 3700 - 7000 A. Several dereddened emission line ratios were used to classify all objects revealing 14 new AGs include one Seyfert 1, two Seyfert 2's, 4 Seyfert 3's, and 7 AGN-like objects.

The analysis of all data yields the following conclusions: (1) About half (37/73) of VLIRGs show AGN-like spectra, corresponding to Sy 1, Sy 2, Sy 3 (Liner) or mixture of Liner and HII region traits. This fraction rises to 73% for ultraluminous galaxies about 10^{12} L_{o}. (2) 56% of the very luminous and 91% of the ultraluminous galaxies are in strongly interacting or merging systems. (3) There are 7 groups of galaxies with at least 3 members and velocity disperions of several hundred km/s. For example, IRAS 23532+2513 is found to be in a compact group with a disturbed starburst galaxy and a Seyfert 1 (Zou + A&A 304, 369). (4) The infrared luminosities increase with decreasing projected separation between the source and its companions. (5) The relation of projected separation and specific

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angular momentum shows that dynamical friction plays an important role even for interacting galaxies with large distances.

D. OPTICALLY SELECTED QUASARS

From the sample given by He & Chen (ApSS 200, 279), a quasar with B = 18.5 and z = 1.662 was found by Wu + (Acta Astron. Sin. 36, 428). More recently, in the Beijing-Arizona-Taiwan-Connecticut (BATC) multi-color survey, a candidate with colors f - g = -0.33 and e - f = 0.1, selected from the color-color diagram of T329 field has been identified as a QSO with z = 1.88 (Chen IAU Symp. 179).

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