COMMISSION 28: GALAXIES

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This report covers the period July 1, 1987, to about June 30, 1990. The task of preparing the individual sections has been carried mainly by members of the Organizing Committee and chairmen of the Working Groups. All authors have to be thanked for this service to the community. The authors were free to emphasize what seemed important to them, rather than to attempt completeness. It is hoped that the abbreviated references are self-explanatory; in some cases the code numbers of Astronomy and Astrophysics Abstracts are used. A + sign stands for *et alii.*

1. Highlights since Baltimore
(J.Gallagher)

Extragalactic astronomy has made excellent progress since Baltimore. Observations of faint galaxies, however, stand out as an area where new techniques have yielded a clearer and sometimes surprising view of the distant universe. I am therefore following the spirit of the last report in presenting my personal selection of highlights from this exciting area of extragalactic astronomy.

I have broken the topic into three general areas. There is no concluding section because the exploration of very faint galaxies is really just beginning, and there are many fascinating problems still to be solved. This report ends with a summary of recent catalogs kindly supplied by J.Lequeux.

I. Distant radio galaxies

Radio sources have led us to the furthest objects that can be claimed to be true galaxies (e.g. 4C41.17 at a redshift of z=3.8; Chambers+). Pioneering work on these distant radio galaxies (RGs) by Spinrad+ and Lilly and Longair predates Baltimore. Most high redshift (z>i) radio galaxies were chosen from the 3C, 4C, or Parkes catalogs, and thus have moderate radio fluxes, despite their great distances. They therefore also have extraordinary radio (and optical) luminosities. Distant RGs are far too luminous to be common in the nearby universe. Using different radio selection criteria, including low radio fluxes, Windhorst+ are working to overcome this Scott effect limitation by finding analogs to more normal classes of nearby radio galaxies.

Spatial distributions and ages of the stellar populations measured in the optical and near IR hold the keys to evolutionary properties of distant RGs. Since optical observations refer to the rest frame ultraviolet in these galaxies, IR measurements are needed to probe old stellar population components. The oldest stellar components then set lower bounds to the elapsed time since galaxy formation. This process of finding the oldest galaxies as a function of lookback time amounts to mapping out the "red envelope" of stellar population colors over redshift, as described earlier for field galaxies by Hamilton.

Spinrad+, McCarthy+, Chambers+, Lilly+, Dunlop+, Djorgovski+, Hammer+, Kron+, and Eisenhardt+ have obtained optical infrared data on distant radio galaxies to measure morphologies, spectra, and broad band spectral energy distributions (SEDs). These data in combination with spectra convincingly show that stars produce most of the luminosity in distant RGs, i.e. that they really are galaxies! Spectra and narrow band images also demonstrate some of the unusual features of these objects: they have galaxy-sized, extended Lyman-alpha emitting regions, AGN-like emission lines (e.g. CIV), and sometimes systematic velocity gradients.

The interpretation of SEDs and optical/infrared morphologies of distant RGs lead to contradictory results. High quality JHK-band images obtained with IR arrays, show that the rest frame red-near IR light, like the rest frame ultraviolet, is often aligned with the radio sources. This is most readily understood as a transient condition. For example, the radio jet may be stimulating star formation, as suggested by De Young, Rees, Miley+, and Daly. Detection of high polarization optical levels in a few cases by Di Serego Alighieri+ suggests more complex processes, such as dust scattering or contributions from non-thermal luminosity sources. But again a rapid evolutionary phase (or connection with the extraordinary radio power?) is implied.

Lilly+, Chambers+, and Dunlop+ emphasize the strong evidence from red/IR SEDs that the stellar populations are not extremely young ($<10^5$ yr). Although there are differences over the exact stellar popula-

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tion ages, estimates for several galaxies of near 1 Gyr are derived from standard Bruzual-type models. Also, only small scatter is observed in the empirical locus of galaxies in the K mag-redshift plane. Eisenhardt+ note that reconciling this "quiet" IR magnitude-redshift diagram with the bizarre morphologies seen in direct IR images should prove "interesting". Furthermore, the unusual natures of these galaxies suggests that they are unlikely to be good standard candles.

Even though formation processes are not yet observed, the present data suggest an extended epoch of rapid star formation (more than a dynamical time) for very luminous young galaxies. Since some high galaxies with z>1 may have been forming stars for at least 1 Gyr, the high star formation rate epoch for these galaxies extends over at least z=1.5. A fuller understanding of the AGB stellar evolution phase will be critical in refining the stellar population age scales, as will better observational stellar population constraints (e.g. from absorption line spectra).

II. Field galaxies

When Longair summarized the evolutionary properties of distant galaxies at the close of IAU Symposium No.124, standard models with little or no evolution in the population of galaxies with redshift looked quite good. His conclusion was primarily based on deep, broad-band photographic surveys from the world's largest telescopes, which extend to galaxies with B=24. For B>24 (very deep surveys), CCDs operating in combination with sophisticated image processing techniques are needed to find and photometer galaxies. Longair also emphasized the need to test standard models through very deep (K>19) IR photometry of galaxies. Very deep optical and IR surveys are now available, and the situation looks more complex.

Tyson has made a confusion-limited very deep survey of field galaxies extending to about B=27 from spectacular CCD images. The main features of this work are the steep slope of the logN-magnitude relationship, leading to a very high surface density of faint galaxies, and the continuation of the bluing trend in color with increasing magnitude in the sense found in earlier photographic studies. Excess numbers of very faint blue galaxies are also seen by Cowie+, who named these "flat-spectrum" galaxies. In the nearby universe, ultraviolet photometry has shown that most flat spectrum galaxies are Magellanic irregulars and related classes of low luminosity galaxies, with $L_B<0.1\ L^*$. These types of dwarfs do not have high enough local densities to produce the observed excesses of very faint blue galaxies.

Spectroscopic surveys are now feasible into the deep photometric survey range. Results from the University of Durham spectroscopic surveys with the AAT have been presented by Ellis, Broadhurst+, Colless+, and more work is in progress. Spectroscopic surveys are also being carried out by Kron and Koo+ and Cowie+. We expect a welcome increase in the number of such surveys as the technology of multi-object spectrographs is combined with sensitive array detectors at more of the world's large optical telescopes.

The spectra of faint galaxies show a change in the stellar content with increasing redshift that is consistent with the bluing of very faint galaxies. Yet the same data sets indicate the N(m)-N(z) distributions are close to those predicted by no-evolution models! Thus we have the paradox of too many faint blue galaxies occurring with the expected normalized redshift distribution derived from the properties of local galaxies!

Better knowledge of very deep sample redshift distributions is helpful in understanding this problem. For example, do very deep surveys contain many high z objects that are young, thereby exacerbating the blue galaxy problem? To get at this issue, Guhathakurta+ and Cowie+ have obtained U-band photometry for their very deep photometric samples. For galaxies with z>3 the Lyman discontinuity moves into the U-band and galaxies should therefore become faint in U. This is not happening; so few of the blue galaxies can be at very high redshifts. Koo has long argued for this interpretation on the basis of photographic colors. Also noteworthy is the lack of success by Pritchet and Hartwick in finding Lyman alpha emission from protogalaxies with the CFHT.

Cowie+ have also obtained very deep JHK photometry for a small area. This work takes us back to the earliest optical cosmological measurements, where exposures were measured in the tens of hours, in this case 22.4 hr with an InSb array detector on the UKIRT telescope. Surprisingly, almost all IR objects have optical counterparts in this field, again suggesting that very high redshift objects are absent. No evidence is found for star-bursting protogalaxies. One object has optical/infrared colors that are consistent with a galaxy having a spiral-like SED near z=2, implying that formation took place at a significantly higher redshift. The primary epoch of field galaxy stellar population formation remains elusive.

To explain the results of deep and very deep surveys, one of the usual simplifications about galaxy evolution must be dropped. Two prime candidates have been emphasized by a number of authors: conservation of the number of galaxies over time, and smooth, monotonic star formation rates as a function of cosmic time. In 1977 A.Toomre pointed out that galaxy-galaxy interaction rates, and thus potentially merger rates, should climb steeply with redshift. So it is possible that galaxy number densities have dropped with time as galaxies interact and merge.

The Durham group emphasizes the potential importance of violations of the second condition if starbursts occur among less luminous galaxies, a recognized possibility since the work of Sandage and Searle+ in the 1960s and 1970s. If the starburst frequency or amplitude increases with lookback time, then more blue galaxies will be seen with increasing survey depth. This view is consistent with the starburst model suggested by Dressler+ to explain the Butcher-Oemler effect in galaxy clusters, a model which is receiving support from detailed stellar population models, e.g. by Alloin and her group as in Jablonka+. It also naturally explains the high [0 II] 3727A emission line equivalent widths seen for faint galaxies by Broadhurst+, Colless+, and Koo+, and results from IRAS deep FIR galaxy surveys recently discussed by Lonsdale+ and Franceshini+. So even though the data do not yet yield a unique result, they evidently exclude the simplest classes of non-evolving galaxy models.

Equally vexing are the vast numbers of faint galaxies. Various researchers, including Koo, Fukugita+, Guiderdoni+, and Cowie+, have noted the difficulty of reconciling high faint galaxy surface densities with the currently favored closed universe models. Universes at the critical density contain small volumes at z>1, and can fit the observed counts only if the galaxy luminosity function does not change with redshift, as assumed by Loh and Spillar. This possibility now seems unlikely to be correct. Large projected densities of evolving faint galaxies are more readily packed into a voluminous open universe without having excessive comoving galaxy volume densities. The possible additional requirement of consistency with a closed universe may provide another significant challenge for this field.

III. Selection effects and gravitational lensing

Selection effects are well established daemons of deep cosmological surveys. Galaxies with high surface brightnesses, non-compact brightness profiles, and small k-corrections will always be preferred in surveys that penetrate to high redshifts. The impact of small k-correction selection can be minimized by remaining at a similar rest frame wavelength with increasing z; i.e. by extending observations into the infrared for very deep surveys. The results from the Elston+ and Cowie+ pioneering deep IR images suggest that these types of problems may not be dominating the current faint galaxy samples. Still, as Phillipps+ have recently reemphasized, extreme caution must be exercised as galaxies in the distant universe will be perceived differently than their nearby brethren.

Effects of gravitational lenses present recently recognized difficulties and opportunities. On the difficulty side, Hammer+ have noted that some high z RGs may owe their observability and unusual structures to gravitational lensing. But gravitational lenses also can be exploited as natural aids to view an otherwise inaccessible distant universe. Spectacular examples are provided by the blue arcs in galaxy clusters discovered by Hoag and interpreted in terms of lensed background objects by Petrosian and Lynds, Hammer+, Soucail+, Le Fever+, and others.

Tyson+ have recently extended this approach to argue that blue galaxies in the field of a galaxy cluster at z=0.46 have been lensed and therefore must primarily be at z>0.9. That this result (disputed by Ellis+) is possibly at variance with the spectroscopic conclusions mentioned above shows that much remains to be learned about the furthest visible galaxies.

IV. Catalogues and Atlases (J.Lequeux)

NB: This catalogue covers the period mid-87 mid-90 with one exception. It does not cover photometry and clusters except a few nearby clusters. If you see incompletenesses please tell me.

1987

Dickey+	A catalogue of galaxies in Hercules	AJ 93 788
Karachenseva	Catalogue of isolated triplets of galaxies	Bull.Inf.CDS 32 81
Arp+	A catalogue of southern peculier galaxies...	Cambridge U. Press
Tully+	Nearby galaxies atlas	Cambridge U. Press
Richter+	HI observations of galaxies in between the local and the Hydra-Centaurus Superclusters	A&AS 68 427
Condon	A 1.49 GHz atlas of spiral galaxies...	ApJS 65 485
Condon+	A 1.49 GHz supplementary atlas of spiral galaxies	ApJS 65 543
Lipovetskij	A catalogue of Seyfert galaxies	Soobsch.Spets.Astrofiz. Obs. 55
Sandage+	A revised Shapley-Ames catalogue of galaxies	Carnegie Inst. Washington
Santagata+	Accurate positions of Zwicky galaxies II, III	A&AS 70 189 and 191
de Souza+	Box-shaped galaxies: a complete list	A&AS 70 465
Hummel+	...A radio continuum survey of galactic nuclei...	A&AS 70 517

Burstein+	Spectroscopy and photometry of elliptical galaxies II	ApJS 64 581
Davies+	Spectroscopy and photometry of elliptical galaxies III	ApJS 64 601
Schweizer	Mass to light ratios of binary galaxies I, II	ApJS 64 411 and 417
de Grijp+	A catalogue of AGN candidates from the (IRAS) PSC	A&AS 70 95
Stryczynski	Ultraviolet properties of normal galaxies	A&AS 70 115
Caldwell	Dwarf ellipticals in the Fornax Clusters I A Catalogue...	AJ 94 5
Leggett+	An IR-optical study of IRAS point sources in the Virgo region	MNRAS 227 563
Soifer+	The IRAS bright galaxy sample II The sample and luminosity function	ApJ 320 238
1988		
Tully	Nearby galaxy catalog	Cambridge U. Press
Takase+	Kiso survey for UV-excess galaxies	Ann.Tokyo A. Obs. 22 41
Berkhuijsen+	A catalogue of the brightest stars in the field of M31	A&AS 76 65
Rice+	A catalog of IRAS observations of large optical galaxies	ApJS 68 91
Wray	The color atlas of galaxies	Cambridge U. Press
Sandage+	Atlas of galaxies useful for...the cosmic distance scale	NASA SP-496
Karachenseva+	A catalogue of low surface brightness dwarf galaxies	Soobsch.Spets.Astrofiz. Obs. 57
Lipovetskij+	The second Byurakan survey III Spectra ...	Astrofizika 29 548
Stepanyan+	Second Byurakan spectral survey VI	Astrofizika 29 247
de Vaucouleurs+	Catalogue of visual and IR photometry of galaxies...	U. Texas
Turner+	Continuum radio emission from Virgo galaxies	PASP 100 452
Kenney+	CO observations of all Virgo spirals brighter than B=12	ApJS 66 261
Tifft+	Uncertainties in 21-cm redshifts I data	ApJS 67 1
Helou+	IRAS observations of galaxies in ther Virgo Cluster area	ApJS 68 151
Fricke+	The group environment of Seyfert galaxies II Spectrophotometry of galaxies in groups	A&AS 77 75
Nelson+	Accurate optical positions for 107 Byurakan objects...	AJ 95 1678
Condon+	Radio identification of UGC galaxies: starbursts...	AJ 96 30
Morris+	Spectrophotometry of active galaxies I The observations	MNRAS 230 639
1989		
Richter	The Hydra I Cluster of galaxies V A catalogue of galaxies	A&AS 77 237
Maia+	A catalogue of Southern groups of galaxies	ApJS 69 809
Huchtmeier+	A general catalog of HI observations of galaxies...	Springer
Busarello+	Atlas of velocity dispersion profiles and rotation curves of E and S0 galaxies	Mem. Accad. Sci. Fis. Matem. Napoli 1
Spellman+	Revised coordinates for 373 selected objects in the Southern galaxy catalogue	PASP 101 638
Zou Zhenlong+	Catalogue of double galaxies in the southern galactic cap	Pub.Beijing A.Obs.12 8
Takase+	Kiso survey for UV excess galaxies IX	Pub.Nat.A.Obs.Japan 1 11
Markarian+	The 1st Byurakan survey. A catalogue of galaxies with UV continuum	Soobsh.Spets.Astrofiz. Obs. 62
Metcalfe+	An extended galaxy redshift survey I The catalogue	MNRAS 236 207
Maza+	Calan-TOLOLO survey I Seyfert galaxies	ApJS 69 349
Hickson+	A photometric catalogue of compact groups of galaxies	ApJS 70 687
Paturel+	An extragalactic data base I The catalogue of principal galaxies	A&AS 80 299 and Obs. Lyon
Sharina+	Dwarf low-surface brightness galaxies in the Fornax cluster	Astrofozica 31 63
Takase	Kiso survey for UV excess galaxies X	Pub.Nat.A.Obs.Japan 1 97
Ferguson	A Catalogue of galaxies in the ... Fornax cluster	AJ 98 367
Hoffman+	HI observations in the Virgo cluster area III ...	ApJS 69 65
Faber+	Spectroscopy and photometry of elliptical galaxies VI data summary	ApJS 69 365
Bothun+	The Wasilewski sample of emission-line galaxies: follow-up CCD imging and spectroscopu and IRAS ...	ApJS 70 271
Knapp+	...early-type galaxies. IRAS flux densities	ApJS 70 329
Salzer+	Observations of a complete sample of em. line galaxies I	ApJS 70 447
Young+	Global properties of IR-bright galaxies	ApJS 70 699

Hoffman+	HI... survey of dwarf galaxies II faint Virgo dwarfs ...	ApJS 71 701
Davies+	Neutral hydrogen observations of southern galaxies	MNRAS 236 171
1990		
MacKenty	Seyfert galaxies I morphology, magnitudes and disks	ApJS 72 231
Schneider+	Northern dwarf and low surface-brightness galaxies I The Arecibo neutral hydrogen survey	ApJS 72 245
Huchra+	The CFA redshift survey: data for the NGP +30° zone	ApJS 72 433
Della Cecca+	A catalogue of X-ray measurements ...of active nuclei	ApJS 72 471
Condon+	A 1.49 GHz atlas of the IRAS bright galaxy sample	ApJS 73 359
Tifft	Properties of the redshift I Data and calibration	ApJS 73 603
Bottinelli+	An extragalactic data base II The HI data	A&AS 82 391
Tifft+	Comparison between 21-cm data....	A&AS 84 47
Ferguson+	A catalogue of galaxies in five nearby groups	AJ 100 1
Argyle+	Optical positions of Seyfert galaxies III	MNRAS 243 504
Irwin+	(Catalogue of Fornax low surface brightness galaxies)	MNRAS 245 289
To be published		
Fouqué	A HI survey of late-type galaxies in the southern hemisphere I	A&AS

2. Structure and Evolution of Galaxies

(J. Lequeux)

There has been since the last report an enormous inflation of the literature on this subject: it contains more than 750 published papers not including catalogues, reviews and proceedings. It will thus be impossible to do justice to all of them, and only general trends can be discussed here. The cited papers are just examples and are not even necessarily the best. We recommand that the interested person looks first at reviews and proceedings, whose list should be rather complete. Another difficulty encountered in writing this report is that it makes less and less sense to separate the morphology of galaxies from their dynamics; the present report will hopefully be the last with such a separation and the future reports of Commission 28 will have to be reorganized.

The following review papers and conference or school proceedings are mainly concerned with the topic. **1987**: *Nearly normal galaxies*, ed. Faber, Springer; *Starbursts and galaxy evolution*, ed. Montmerle+, Ed. Frontières; *Evolution of galaxies*, ed. Palous, Pub. Astron. Inst. Czech. Acad Sci. *69*; *Extragalactic Astronomy*, Vorontsov-Velyaminov+, Harwood Acad. Pub; *Observational evidence of activity in galaxies*, IAU Symp. 121, ed. Khachikian+, Kluwer; *Structure and dynamics of elliptical galaxies*, IAU Symp. 127, ed. de Zeeuw, Kluwer; Soifer+, *The IRAS view of the extragalactic sky*, ARA&A 25 187; *Star formation in galaxies*, ed. Lonsdale-Persson, NASA CP-2466. **1988**: *Globular cluster systems in galaxies*, IAU Symp. 126, ed. Grindlay+, Kluwer; *Molecular clouds in the Milky Way and other systems*, ed. Dickman+, Springer; *Galactic and extragalactic star formation*, ed. Pudritz+, Kluwer; *Origin, structure and evolution of galaxies*, ed. Fang Li Zhi, World Scientific; Ruzmaikin+, *Magnetic fields of galaxies*, Kluwer; *Cooling flows in clusters and galaxies*, ed. Fabian, Kluwer; Tenorio-Tagle+, *Expanding superstructures in galaxies*, ARA&A *26* 145; Telesco, *Enhanced star formation and infrared emission in the centers of galaxies*, ARA&A *26* 343; Binggeli+, *The luminosity function of galaxies*, ARA&A 26 509. **1989**: *Active galactic nuclei*, IAU Symp. 134, ed. Osterbrock+, Kluwer; *The world of galaxies*, ed. Corwin+, Springer;Fabbiano, *X-rays from normal galaxies*, ARA&A *27* 87; Hodge, *Populations in local-group galaxies*, ARA&A *27* 139; Kormendy+, *Surface photometry and structure of elliptical galaxies*, ARA&A 27 235; *Molecules in external galaxies*, ed. Combes+, Highlights of Astron. *8* 573; *Evolutionary phenomena in galaxies*, ed. Beckman+, Cambridge U. Press; *Evolution of galaxies...*, ed. Appenzeller+, Springer; *Extranuclear activity in galaxies*, ed. Meurs+, ESO. **1990**: *Galactic and extragalactic magnetic fields*, IAU Symp. 140, ed. Beck+, Kluwer; *The interstellar medium in galaxies*, ed. Thronson+, Kluwer; *Windows on galaxies*, ed. Renzini+, Kluwer. *Dynamics and interactions of galaxies*, ed. Wielen, Springer. **To be published**: *Dynamics of galaxies and their molecular cloud distribution*, IAU Symp. 146, ed. Combes+; *Paired and interacting galaxies*, IAU Coll. 124, ed. Sulentic; *Bulges in galaxies*, ESO-CTIO Conf., La Serena, ed. Terndrup+; *Dynamical and chemical evolution of galaxies*, ed. Ferrini+, Giardini Ed. Pisa.

Papers concerned with the topic can also be found in: **1986**: *Star clusters and associations*, ed. Balazs, Pub. Astron. Dept. Eötvös Univ. *8*; *Radio continuum processes in clusters of galaxies*, ed. O'Dea+, NRAO workshop Nr. 16. **1987**: Binney+ *Galatic dynamics;* Princeton U. Press;*Stellar evolution and dynamics in the outer halo of the Galaxy*, ed. Azzopardi+, ESO; *Interstellar magnetic fields*, ed. Beck+, Springer; *Infrared astron-*

omy with arrays, ed. Wynn-Williams+, U. Hawaï; *High-redshift and primeval galaxies*, ed. Bergeron+, Ed. Frontières; *L'activité dans les galaxies*, ed. Stasinska, les Ed. de Phys.; *Theory and observational limits in cosmology*, ed. Stoeger, Libreria editrice Vaticana; *Magnetic fields and extragalactic objects*, ed. Asseo+, les Ed. de Phys. *Exploring the Universe with the IUE Satellite*, ed. Kondo+, Reidel. **1988**: *X-ray emission from clusters of galaxies*, ed. Sarazin, Cambridge U. Press; *Towards understanding galaxies at high redshifts*, ed. Kron+, Kluwer; *Supernova remnants and the interstellar medium*, IAU Coll. 101, ed. Roger+, Cambridge U. Press; *Galactic and extragalactic radioastronomy*, ed. Verschuur+, 2d. ed., Springer; *Comets to cosmology*, 3d. IRAS Conf., ed. Lawrence+, Springer; *Millimeter and submillimeter astronomy*, ed. Wolstencroft+, Kluwer; *Progress and opportunities in southern hemisphere optical astronomy*, ed. Blanco+, Astron. Soc. Pacific; *New directions in spectrophotometry*, ed. Philip+, Davis Press; *New ideas in astronomy*, ed. Bertola+, Cambridge U. Press; *Hot thin plasmas in astrophysics*, ed. Pallavicini, Kluwer; *Dust in the Universe*, ed. Bailey+, Cambridge U. Press; *Astronomia extragalactica*, Bol. Acad. Nat. Sci. Cordoba *58* 177; *The extragalactic distance scale*, ed. van den Bergh+, Astron. Soc. Pacific; *Applied mathematics, fluid mechanics, astrophysics*, ed. Binney+, World Scientific. **1989**: *Dynamics of astrophysical disks*, ed. Sellwood, Cambridge U. Press; *Physics and chemistry of interstellar molecular clouds*, ed. Winnewisser+, Springer; *Interstellar dust*, IAU Symp. 135, ed. Tielens+, Kluwer and NASA-CP 3036; *Infrared spectroscopy in astronomy*, 22d ESLAB Symp., ed. Kaldreich, ESA-SP 290; *The epoch of galaxy formation*, ed. Frenk+, Kluwer. **1990**: *Hot spots in extragalactic radiosources*, ed. Meisenheimer+, Springer. **To be published**: *Wolf-Rayet stars and interrelations with other massive stars in galaxies*, IAU Symp. 143, ed. Hidayat+; *The interstellar disk-halo connection in galaxies*, IAU Symp. 144, ed. Bloemen.

1. Elliptical and lenticular galaxies

The main trend in the study of these galaxies has been the realization that they are much more complex than originally thought. The old idea that ellipticals were formed by a non-dissipative process within a short time is no more tenable in this simple form although there is still some truth in it. It is already difficult to account in this simple picture for the well-established metallicity gradient and luminosity/metallicity relation in ellipticals (Couture+ AJ *96* 866; *99* 540; Franx+ AJ *98* 538; Vader+ A&A *203* 217), which may be due to early galactic winds (Franx+ ApJ *359* L41; Mathews+ AJ *97* 42; Matteucci+ A&A *185* 51). It is even more difficult to account for the variety of structures: presence of a disk (*disky* Es) or of a box or peanut-shaped bulge (*boxy* Es) (Bender+ A&A *193* L7, *205* 375;Nieto+ A&A *215* 266; Simien+ A&A *227* 11; Michard+ A&A *232* L9) the latter being often attributed to the merging of two galaxies. The small cores in dwarf Es are signatures of dissipative collapse, merger or not (Kormendy ApJ *342* L63). It has been suggested that nucleated dwarf Es are dwarf irregulars stripped from their gas (Ferguson+ ApJ *346* L53) but not all dwarf Es (Gallagher + AJ *98* 538). The statistics of globular clusters puts somewhat in doubt the idea that cD galaxies with their giant envelopes are the product of merging (Pritchet+ ApJ *355* 410) although the idea that at least part of the ellipticals result from merging of spirals is gaining ground in general (see the report on dynamics).

Although most of the stars in Es have been born at early times there is ample evidence for later star formation from photometry (Bothun ApJ *350* 73) or from spectroscopy from the UV (Boulade+ AJ *96* 1319) to the visible (Bothun+ ApJ *324* 123; Bica+ A&A *195* 76, 81; *202* 8; *228* 23) and to the near-IR (Davidge AJ *99* 561). The far-UV excess present in a fraction of the Es and which is known to be correlated with metallicity (Burstein+ ApJ *328* 440) and is more frequent in boxy Es (Longo+ A&A *227* L11) is now attributed to AGB stars of intermediate age turning blue before experiencing pulses due to high metallicity (Barbaro+ ApJ *337* 125; Bertelli+ ApJ *339* 889; Brocato ApJ *349* 458). There is also gas and star formation now in a large fraction of Es. Not only is dust absorption (Véron-Cetty A&A *204* 28) and far-IR dust emission detected in a large fraction (Knapp+ ApJS *70* 329) but this dust is often hot indicating heating by young stars (Thronson+ ApJ *319* L63). HI (Kim+ ApJ *330* 684; Walsh+ ApJ *352* 532) and molecular gas (Huchtmeier+ A&A *198* L17; Gordon ApJ *350* L29; Wiklind+ ApJ in press; Lees+ in preparation) has been detected in many Es although only in moderate quantities. Star formation is mostly visible indirectly through ionization of the gas although spectroscopy often suggests LINER-type ionization (Kim ApJ *346* 653). These phenomena can be due either to merging or to cooling flows. Merging is likely in many cases where the gas lies in disks or rings aligned or not along the major axis of the galaxy and even counter-rotating (Bertola+ Nature *335* 619; Schweizer+ ApJ *338* 770); counter-rotating stellar disks or cores can be a later manifestation of the same thing (Franx+ ApJ *327* L55). A superb example is NGC 5128 where ionic, atomic and molecular lines have been well studied in emission and even absorption (Phillips+ ApJ *322* L73; Israël+ A&A *227* 342 and preprint). Cooling flows around massive Es also contain cold gas (McNamara+ ApJ *360* 20), even molecular (Lazareff+ ApJ *336* L13) and there are indications for star formation (Romanishin ApJ *323* L113) although stars of small mass seem favored (O'Connell+ AJ *98* 180); the accreting mass must disappear in some way! The gas may also "feed the central monster" producing a radio galaxy and sometimes infalling gas has been seen around radio galaxies (Mirabel ApJ *352* L37).

Lenticular galaxies are a mixed bag (van den Bergh ApJ *348* 57) which are not easy to distinguish from Es one one hand and Sas on the other and whose origin and evolution are uncertain. They also often contain dust (optical, IRAS), atomic (Burstein AJ *94* 883) and molecular gas (Sage+ ApJ *344* 204; Thronson+ ApJ *344* 747; Wiklind+ A&A *225* 1), in general in a central ring or/and in an outer ring which may be very tilted with respect to the stellar disk (Van Driel+, A&A in press and several A&A papers), suggesting accretion of external gas or merging (these galaxies may also be boxy: Whitmore+ ApJ *324* 741). Star formation is often conspicuous (Bally+ AJ *97* 69). However there is still much to do for understanding these objects.

More CCD stellar photometry has been done on the dwarf spheroïdals, showing the frequent presence of an intermediate-age population (Carina: Mighell A&AS *82* 1, 207; Sculptor: Eskridge AJ *96* 1614 and previous AJ papers). Mould+ (ApJ *354* 438) have resolved Andromeda I. The red giants in Fornax have been studied in details (Lundgren A&A *233* 21).

2. Spiral and irregular galaxies

Enormous progresses in the study of these objects have come from far-IR studies with IRAS, and more recently from observations in the near-IR with spectrometers and imaging devices, of the CO molecule with several radiotelescopes and interferometers and of CCD stellar photometry; these will be emphasized here.

Surveys have revealed many dwarf Irr in Virgo (Binggeli+ A&A *228* 42) which can be accounted for by contagious star formation models (Tyson+ ApJ *329* 618) and might be formed by accretion on dwarf Es (Silk+ ApJ *322* L59) although opposite views exist. Blue compact dwarfs form a mixed bag (Kunth+ A&A *204* 10). Many new such objects have been found but only a few have very low metallicities (Augarde+ A&A *185* 4) showing that real young galaxies must be very rare: objects comparable to IZw18 (Dufour+ ApJ *350* 149) are SBS 0335-052 (Izotov+ Nature *343* 238) and GR8 (Skillman+ A&A *196*, 31; Moles+ A&A *228* 310); even the latter shows an exponential light profile (Carignan+ AJ *99* 178). A very interesting discovery is that of low-surface brightness galaxies being generally gas-rich (Bothun+ AJ *94* 23; Davies+ MNRAS *231* 69P, *244* 385), sometimes blue (Impey+ ApJ *330* 618) and even with a Seyfert nucleus (Impey+ ApJ *341* 89). Extragalactic HI clouds with an associated low-luminosity galaxy (Impey+ ApJ *351* L33; Djorgovski AJ *99* 31) may be related. The origin of these objects is not well understood (e.g. Bosma+ A&A *198* 100).

Spectral synthesis has shown that normal nuclei or bulges in spirals contain generally a mixture of populations of different metallicities and ages (Bica+ op. cit.; Schmidt+ MNRAS *243* 620).

Amongst interesting topics concerning disks in spirals is the detailed study of their HI distribution. It shows large empty bubbles which are considered as due to the collective effect of supernovae explosions and stellar winds (Deul+ A&A *229* 362). These may also be responsible (McLow+ ApJ *337* 141) for the high-velocity HI detected in M 101 (van der Hulst+ AJ *95* 1354) and for the gas seen high above the plane in edge-on galaxies (Dettmar AA *232* L15). Vertical holes dug in the disk are taken as responsible for the fact that supernovae are preferentially seen in face-on galaxies (van den Bergh A&A *231* L27; Guthrie A&A *234* 84). For explaining some statistical properties, it has been suggested that the disks contain much more dust than usually thought (Valentijn, Nature *346* 153; Disney+ MNRAS *239* 939) but this is disputed (Kodaira AJ *96* 1593). Many measurements have been made of the polarization of the non-thermal radio emission in disks, with the result that the magnetic field is usually bisymmetric along the main arms (Beck+ A&A *222* 58 and other A&A papers). This is accounted for by dynamo theories (Ruzmaikin+ A&A *230* 284; Chiba+ MNRAS *238* 621).

"Normal" star formation in S and Irr galaxies has been actively studied. One developing method is the direct detection and counts of the brightest stars by CCD photometry (e.g. Berkhuijsen+ A&A *214* 68 and Hodge+ ApJ *329* 651 for M31; Wilson+ AJ *99* 149 for M33; Ferraro+ MNRAS *241* 433 for WLM). The HR diagrams allow an estimate of the recent star formation rate (SFR) and of the initial mass function. This function looks more or less universal although M 31 seems to lack very massive stars (Humphreys+ AJ *99* 84). However the brightest stars are most often composite systems (Humphreys+ ApJ *318* L69) making somewhat problematic their use as standard candles. Planetary nebulae appear to be better candles (Ciardullo+ ApJ *344* 715 and other ApJ papers). A lot of work has been devoted to Wolf-Rayet stars which are good indicators of massive SF (Massey+ PASP *99* 816; Arnault+ A&A *224* 73). The behaviour of these objects is better understood (Smith+, Maeder A&A in press) and their strong sensitivity to metallicity confirmed (Azzopardi+ A&A *189* 34). It is also possible to obtain information on the SFR of massive stars by observing their far-UV radiation (Bohlin+ ApJ *352* 55; Buat+ A&A *220* 49) (the B luminosity is not a good tracer: Sage+ ApJ *342* L15). HII regions being ionized by young massive stars offer another possibility which has been much explored. Many surveys of HII regions in nearby galaxies have been published from optical and radio observations (e.g. Deharveng+ A&AS *73* 407; Petit+ A&AS *74* 475; Kaufman+ ApJ *319* 61) and the properties of HII regions discussed in details: fine structure, excitation of molecular hydrogen (Israël + MNRAS *236* 89), size versus galaxy type (Kennicutt ApJ *334* 144). Note that HII regions exhibit often some non-thermal radio radiation due to supernovae remnants inside or close-by (Condon+ ApJ *357* 97). When these different SFR tracers are compared on finds usually good agreement (e.g. Buat+ A&A *185* 33), suggesting again the universality of the initial mass function as they are not sensitive to the same mass ranges.

A central question in the study of star formation in galaxies is its relation with the amount of gas, both atomic and molecular. In a simple model, the atomic gas is given by HI measurements (no problem here) and the amount of molecular derived from the intensity of CO line(s) using some conversion factor. The SFR can be derived from star counts or from one of the above tracers or from the far-IR emission assuming that it is mainly due to dust heated by young hot stars, or even from the strength of the 3.28mm interstellar feature (Mitzutani+ ApJ *346* 675). As the non-thermal radio emission is known to be very well correlated to the far-IR emission one can also think of using it as a tracer, the idea behind this correlation being that the radio emission comes from electrons accelerated by supernova remnants, themselves mainly coming from short-lived massive stars (Chi+ MNRAS *245* 10). Actually L(IR) is only proportional to the power 0.8-0.9 of L(radio) (Cox+ MNRAS *235* 1227; Devereux+ ApJ *340* 708) but a better proportionality is obtained if one considers only the warm component of dust that is supposed to better reflect the SFR (Fitt+ MNRAS *233* 907; Hummel+ A&A *199* 91; Wunderlich+ A&AS in press). Another complication comes from the fact that the FIR radiation decreases with decreasing metallicity for a given SFR (Hunter+ ApJ *336* 152; Arnault+ A&A *205* 41). The progress of observations is such that it is possible to map all or most of the above quantities in several nearby galaxies (e.g. for M33 Rice+ ApJ *358* 418; for M81 Brouillet+ A&A *196* L17 and in press). Although stars are known to form in molecular clouds, a surprising result is that the SFR (from far-UV) correlates better with HI + H_2 than with H_2 alone (Buat+ A&A *223* 42). It is impossible to discuss here the distribution of molecular gas because of the enormous amount of data coming out of the mm radiotelescopes and interferometers (see IAU Symp. 146, in press). It is interesting to mention that the equivalent of the galactic Giant Molecular Clouds can now be seen in nearby galaxies (e.g. for M31 Lada+ ApJ *328* 143; Casoli+ A&A *198* 43; Vogel+ ApJ *321* L145) and that their relations with atomic gas, HII regions etc. can be studied more easily than in our own Galaxy.

In spite of this wealth of data on star formation (including results of UV spectral synthesis for blue compact dwarfs: Fanelli+ ApJ *334* 665), on the distribution of gas and dust and also on chemical abundance gradients (e.g. Vilchez+ MNRAS *235* 633) it is surprising that so little has been done on modelling the evolution of S and Irr galaxies. The reason is probably that many people have been deterred by the extreme complexity of the problem and by the large number of free or arbitrary parameters (e.g. Tosi A&A *197* 33, 47).

One major discovery made with IRAS is that of galaxies emitting an enormous power in the far-IR which can reach several 10^{12} L_O. This phenomenon is due either to a Seyfert nucleus or to a very strong starburst, or to both (e.g. Norris+ MNRAS *234* 773). There is ample evidence that these galaxies are mostly strongly interacting systems or mergers (Telesco ApJ *329* 174; Melnick+ A&A *231* L19; double nuclei: Carico+ ApJ *349* L39; Graham+ ApJ *354* L5; Bushouse+ ApJ *359* 72; etc.) with a preference for early-type and barred spirals (Dressel ApJ *329* L69). Bars (which exist in many interacting systems: Arsenault A&A *217* 66; Telesco ApJ in press) appear to induce similar phenomena even in apparently isolated galaxies like NGC 253 (Canzian+ ApJ *333* 157), NGC 1068 (Thronson+ ApJ *343* 158), IC 342 (Ishizuki+ Nature *344* 224) or NGC 6946 (Weliachew+ A&A *199* 29). The starburst is usually limited to the central few kpc although it may occasionally cover a much larger area as in the case of Mkn 171 = Arp 299 (Casoli+ A&A *224* 31) or lie partly in between the interacting components as in NGC 4485/90 (Thronson+ ApJ *339* 803; Stanford+ ApJ *349* 492). One problem is to distinguish between Seyfert and starburst phenomena in those systems. Seyferts are recognized by the usual broad lines and peculiar optical excitation, but this is not always easy as the systems contain large amounts of obscuring dust. Point-like radio emission (but see Norris+ ApJ *359* 291), X-ray emission (Green+ ApJ *339* 93) or characteristic far-IR colors (Rowan-Robinson+ MNRAS *238* 523; Hill+ ApJ *330* 737) are of easier use. The whole set of star-formation tracers have been used to find the starburst: Wolf-Rayet features (Armus+ ApJ *326* L45, *347* 727), recombination and other lines especially in the near-IR (Moorwood+ A&A *203* 278), radio continuum (Dahari+ ApJS *67* 249; Wilson A&A *206* 41), 3.28mm interstellar emission band (Mouri+ ApJ *356* L39; Dennefeld+ A&A *227* 379; Smith+ MNRAS *241* 425) which is absent in true Seyferts (Desert+ A&A *206* 227), and mainly emission by the CO molecule (Solomon+ ApJ *334* 613). Concentrated CO has been discovered in many Seyfert galaxies especially Seyfert 2 (Heckman+ ApJ *342* 735; Meixner+ ApJ *354* 158) and even in quasars (Barvainis+ ApJ *337* L69; Sanders+ ApJ *335* L1; A&A *213* L5), showing that a starburst often coexists with an active nucleus. The amount of H_2 present can be rather large (Sanders+ ApJ *324* L55) although not well determined as the conversion factor from CO intensity is uncertain, and the efficiency of the SFR as derived from the far-IR flux is usually enhanced by a few times (Jackson+ ApJ *337*, 680). The starburst galaxies often show millimeter emission of molecules ocurring at high densities, showing the extreme conditions present there (e.g. Solomon+ ApJ *348* L53; N.Q.Rieu+ A&A *220* 57; Henkel+ A&A *229* L5). This includes molecular hydrogen vibrationally excited mainly by shocks (Kawara+ ApJ *321* L35; Moorwood+ A&A in press). These extreme conditions favor HI absorption and OH megamasers excited by the IR radiation (Martin+ A&A *208* L13; Henkel+ A&A *229* 431 and ref. herein). There have been suggestions for an evolution starburst-AGN (Rieke+ ApJ *325* 679; Sanders+ ApJ *328* L35; Norman+ ApJ *332* 124). It is impossible here to report on the detailed studies now available for many starburst galaxies, some very famous like M 82 or NGC 253.

3. Effects of environment

It is clear that galaxies in groups or clusters show differences with isolated galaxies. This is true for dwarf Es (Ishikawa+ AJ *96* 62) and for giant Es and SOs (Bower+ AJ *99* 530; Alloin+ A&A *181* 270) apart from the wellknown c D phenemenon. Vigroux+ (AJ *98* 2045) have found a segregation in the star-forming early-type galaxies in a nearby cluster similar to the Butcher-Oemler segregation in distant clusters.

Spirals are deficient in HI in the central regions of clusters (Warmels A&AS *72* 19, 57, 427; *73* 453; Huchtmeier+ A&A *210* 1; Gavazzi+ ApJ *346* 59) but there is little effect on CO (Kenney+ ApJ *344* 171). The environmental effects on star formation, far-IR, etc. in clusters are somewhat controversial probably because they are not as strong as the HI effect. The effects on the rotation curves (Rubin+ ApJ *333* 522; Whitmore+ ApJ *333* 542) are also controversial (Guhatakurta+ AJ *96* 851 but see Rubin+ AJ *98* 1247; Balkowski+ in preparation). Usually these effects are attributed to stripping by the intergalactic cluster gas, but there are doubts: tidal effects may play a dominant role (Byrd+ ApJ *350* 89). A clear case of tidal stripping has been discussed by Combes+ A&A *203* L9.

3. Galactic Dynamics
(K.C.Freeman)

This is not a complete review of galactic dynamics - it is intended to indicate trends in galactic dynamics over the last few years.

Conferences and reviews

Nearly Normal Galaxies (44.012.031), Structure and Dynamics of Elliptical Galaxies (44.012.032), Stellar Evolution and Dynamics in the Outer Halo of the Galaxy (44.012.051), Galactic Dynamics (44.003. 028), Starbursts and Galaxy Evolution (45.012.018), Globular Cluster Systems in Galaxies (45.012.042), The Few Body Problem (45.012.051), Dark Matter in the Universe (45.012.088), Evolution of Galaxies (46.012.012), Cooling Flows in Clusters and Galaxies (46.012.021), Largescale Structures of the Universe (46.012.078), Evolutionary Phenomena in Galaxies (50.012.040), Dynamics of Astrophysical Disks (50.012.053), CC Lin Symposium (50.012.072). See also 44.151.034, 44.155.025, 46.155.070, 50.155.080 and 50.157.182 for individual reviews.

Disk galaxies

Work on the spiral structure problem emphasised the dynamics of spiral modes and its application to real spirals. Some of the trends can be seen in the following examples: nonlinear coupling of spiral modes and its relevance to effects seen in simulations (44.151.029), 45.151.089; nonlinear rigidly rotating spiral wave solutions as a balance between diffusion and differential rotation (46.151.057); global spiral modes in disks of gas and stars (45.151.037); propagation of spiral density waves in gaseous disks in response to external periodic disturbances (49.151.073). Observational applications included fourier analysis of spiral components in 16 spirals, showing that the 2-armed component dominates (46.157, 304); optical tracers of spiral arm resonances, and application to NGC 1566 (ApJ 355 52). A computer-generated N-body model with cooling showed that two-armed spiral structure can survive for several rotation periods (ApJ 356 L9).

Formation of spiral structure through encounters with companion galaxies was also actively investigated: generation of spiral patterns by companions on elliptic orbits (45.151.155, 46.151.038, 49.151.057); formation of leading spiral arms in retrograde galaxy encounters (49.151.020, 50.151.105 & 156); simulation of M51's spiral structure by tidal passage of its companion (AJ 99 1798); enhanced bar formation in interaction (44.151.033). A study of the gas response to an oval potential (44.151.097) showed that even a 1% oval perturbation would lead to spiral structure.

The effects on disk stability of various parameters were studied, such as rotation and shear (45.151. 147), a compact bulge and hot inner disk (44.151.009), radial velocity dispersion, gas surface density (46.157. 354) and radial variations of Q (46.157.215). The fraction of stars in retrograde orbits is important for the stability of disks to m=1 modes (50.151.143, MN 243 263). Disk stability was studied in modified dynamics (MOND) (49.151.016).

The effect of cosmic infall and angular momentum reorientation can produce warped and tilted galactic disks (49.151.034). Persistent warps in disks were modelled as discrete bending modes in the presence of a flattened galactic halo (46.151.041). An overview of warp structure in disks (ApJ 152 15) established rules for warp behaviour. The kinematics of high velocity clouds suggests that our Galaxy is a polar ring galaxy (45. 155.067). Several disk galaxies show ripples in their outer disks (45.157.234) which probably result from interaction with other galaxies (46.151.110).

The local column density of matter in the solar neighborhood is controversial: see (50.012.079) for an overview. The vertical dynamics of disks is a closely related problem: the evolution and shape of the local velocity ellipsoid is explained through secular heating by spiral waves and scattering of energy in the z-direction by massive molecular clouds (44.151.142; see also 50.151.142).

The exponential disk may result from the viscous evolution of the early galactic disk (44.157.273, 49.151.027). The radial dependence of the velocity dispersion in galactic disks, including the disk of our Galaxy, is fairly close to that expected for an exponential disk of constant vertical scaleheight (45.157.185, 49.155.006, 50.157.065).

The bulges of disk galaxies are often box or peanut-shaped (44.157.308, 46.151.018). The bulge of IC 4767 has an extreme X-like structure, suggestive of formation through an accretion event (45.157.089). Some bulges appear triaxial (50.157.186 & 187). For other work on bulge dynamics, see 45.155.057 (the Galaxy), 49.157.054 (M31) and 49.157.087 (NGC 4594).

Internal motions of gas were studied in many spiral galaxies. The HI structure of the outer regions of M33 and NGC 3344 is more complex than conventional warp models (49.157.013). Noncircular gas motions are seen in some galaxies (49.157.129, 49.157.077, 50.157.099). HI observations of the low surface brightness disk system NGC 5963 suggest that its dark halo is more concentrated than usual (45.157.202). The rotation curve for NGC 3198 is flat out to a radius of 11 scale lengths (50.157.104). HI rotation data for 21 Virgo cluster spirals show no obvious environmental effects on their mass distributions (46.157.029; see however 50.157.192). The ratio of disk mass to dark halo mass appears to vary with luminosity (ApJ 356 83). The search for high velocity gas in face-on spirals (like the high velocity clouds in our Galaxy) promises to be an important subject (46.157.341, 50.157.161).

S0 galaxies probably comprise several distinct kinds of objects (ApJ 348 57). Conclusions from HI observations of S0 suggests that they have dark halos (45.157.037) as usual for disk galaxies. There is disagreement about the origin of the gas in S0's: it may be accreted from nearby galaxies (45.157.205) or be internal in origin (46.157.170, 50.157.013 & 139).

Central supermassive black holes may be present in some disk galaxies: M31 (45.157.151, ApJ 353 118) shows kinematic evidence for a black hole of about 10^7 to 10^8 $M_{\odot}$, but see 45.157.162 for an alternative explanation of the observations. The stellar kinematics of NGC 4594 again suggest a central black hole of about 10^9 $M_{\odot}$ (46.157.031 & 371).

HI observations of later-type barred spirals show streaming in the spiral arms, and noncircular motions associated with the bar potential. In some examples, there is little HI in the bar region itself (49.157. 033, 50.157.026, 50.157.027, ApJ 348 456). Observations of the Magellanic system NGC 4027 show no evidence for retrograde stellar streaming (50.157.031).

Many observations were made of stellar kinematics in SB0 galaxies. NGC 6684 appears to have a triaxial bulge (45.157.025). Retrograde streaming or gas is seen in NGC 4546 (44.157.082). Noncircular stellar motions and possible retrograde stellar streaming were observed in several SB0's (45.157.184, 49.157.010).

50.151.001 gives an overview of orbit properties in barred galaxies. The importance of the 4:1 resonance in different models of barred galaxies is discussed in 46.151.007. The gas and stars contribute in different regions to the selfconsistency of barred galaxies (50.151.132). The gas response to an off-center bar is described in 49.151.026. The gravity fields of non-axisymmetric disks can be derived from those of axisymmetric disks (49.151.040).

Elliptical galaxies

Stability of elliptical galaxies to bar forming modes was a major issue. Some general stability tests were devised (45.151.151, 50.151.042). A central point mass has a stabilizing effect on nonradial modes in anisotropic systems (45.151.032). Only the most anisotropic systems in a wide range of Plummer models are unstable (45.151.117). Stable anisotropic models of real ellipticals may need to be nonspherical (44.151.040). In a family of anisotropic models, only the unrealistic members are dynamically unstable (49.151.023). Various orbit families contribute to stabilizing and destabilizing nonrotating triaxial models (50.151.126).

The questions of triaxiality, minor axis rotation, and isophote twists received much attention. One in three ellipticals shows minor axis rotation (45.157.045 & 110, 50.157.166 & 262). Projected Stäckel models show no isophote twist (45.151.012). Models constructed include selfconsistent perfect triaxial systems, using Schwarzschild's method (44.151.129), anisotropic tensor virial models with rotation or verticity (45.151.083, 49.157.062), and a triaxial N-body system rotating about its minor axis (49.151.022). The kinematics of gas in triaxial systems was studied (45.151.092, 50.151.133).

Important discoveries were made about the cores of ellipticals. Rapidly rotating and counter-rotating cores are found in several ellipticals (45.157.220, 46.157.040 & 155). These are believed to result from accretion of small dense companion galaxies (50.151.104).

There is evidence for black holes or other compact systems at the centers of some ellipticals (44.157. 126, 45.157.227, 49.157.015). The central object in M32 has a mass of 3-10.10^6 $M_\odot$ (44.157.339, 45.157.087). There is no evidence for black holes in ellipticals from emission by hot accreted gas (45.157.279). For M87, the stellar kinematics do not require a central black hole, but are consistent with a black hole of up to 10^9 $M_\odot$ (ApJ 348 120).

A substantial fraction of ellipticals have faint disk features (A&A 217 35, MN 242 24P). Box structure in ellipticals is sometimes pure, sometimes coexists with weak disklike features (49.157.088). From measures of rotational velocity and velocity dispersion, ellipticals with weak disk components are consistent with rotational flattening, while those with boxshaped isophotes are more consistent with flattening by anisotropy and may be triaxial (45.157.083 & 109).

Many ellipticals show Malin-Carter shells (45.157.212 & 013). These shells are generally believed to result from merger debris (46.151.029, 44.151.098, 50.151.010 & 125). Many shell ellipticals show evidence for recent nuclear star formation (46.157.254). Alternative theories stress the importance of the interstellar gas for shell formation (44.157.113 & 197, 45.151.008).

The 2-D relationship between absolute magnitude, velocity dispersion and surface brightness for elliptical galaxies is known as the fundamental plane (e.g. ApJ 313 59; A&A 230 L17).

The basic dynamics underlying the structure of elliptical galaxies has been studied with statistical mechanics techniques (44.151.042 & 127), including maximum entropy models (44.151.043, 45.151.096), and dissipationless collapse (45.151.125, ApJ 354 33). See also PAS Japan 42 205. A simple new mass model to represent the $R^{1/4}$ law for ellipticals is given in ApJ 356 359.

Other highlights: The kinematical broadening function for early type galaxies can be recovered by a new method (A & A 229 441). Fourth-moment methods have been developed to estimate kinematic anisotropy in stellar systems (AJ 99 1548). N-body experiments indicate how ellipticals can form through the merging of compact groups of galaxies (49.151.004). Spectroscopy of globular clusters in M87 shows that the M/L ratio increases with radius (AJ 99 1823). The elliptical IC 2006 has a counter-rotating outer ring of HI, which provides strong evidence for a dark corona in this system (49.157.078).

Interacting galaxies

Observations of structure and kinematics in interacting galaxies can now be compared directly with simulations: for example see 46.157.014 & 015, 49.157.029 and AJ 99 1461. Dark matter is important in the merger process (44.151.032, 46.151.030), as a sink of energy and angular momentum. Simulations of gas dynamics in interactions show tidal triggering of starbursts and nuclear activity (46.151.043, 50.151.027): see also 46.157.330. Star formation may be related to high energy cloud collisions (ApJ 349 480). The merger system NGC 520 shows a counter-rotating core (ApJ 355 59). Phase densities and the merger picture are discussed in 49.151.072.

The detailed properties of elliptical merger remnants may show residual effects of their previous strong tidal interactions (50.157.199, ApJ 348 515, MN 239 257, MN 242 311). Almost every galaxy in groups and clusters has undergone tidal interaction within a Hubble time (45.157.018). From the frequency of interacting galaxies, most interacting pairs were already bound (44.151.005).

Some ringed galaxies are formed by the passage of a small companion galaxy through the disk of the parent (44.151.001 & 149, 45.151.144, 49.151.046). The "folded ring" galaxy Arp 144 probably formed through the encounter of two galaxies of similar mass (45.157.104, 46.157.017).

Selfgravity is important in estimating the orbital decay times of satellite orbits around a larger galaxy (46.151.049, 49.151.045, 50.151.025, MN 243 199). For orbital decay in an oblate system, the initial inclination of the satellite orbit is remembered through the decay (46.151.017). The slow orbital decay rates and mass loss rates for compact elliptical companions suggests that they were formed as low mass systems (44.157.212). Orbits of satellites around disk galaxies could possibly be stationary, with a balance of dynamical friction forces from disk and halo (45.151.020).

Several examples of counter-rotating gas and stars in dustlane ellipticals, suggest that the dustlane material is acquired through accretion (45.157.248, 46.157.219). Evidence that the halo population of our Galaxy comes from accreted satellites is discussed in 49.155.001; see also 50.155.114.

Dwarf galaxies

HI observations of internal motions for many dwarf irregulars include some that are intrinsically very faint (45.157.009, 034, 199; 46.157.136 & 310; 49.157.073, 50.157.240, AJ 99 178 & 547). The results are usually interpreted as indicating a dominant contribution of dark matter to their gravity fields. Controversy continues about interpretation in terms of the MOND theory of gravity (46.157.310, 50.157.183).

The M/L ratios for the UMi and Dra dwarf spheroidal (dSph) galaxies indicate high densities of dark matter. For the other dSph's, the evidence for dark matter is not so compelling (44.157.096 & 114, 50. 157.076, MN 244 701). The large velocity dispersions observed in some dSph's could possibly be associated with interaction with the galactic tidal field (49.157.233). The low central concentration of dwarf ellipticals may result from gas ejection (50.151.144, 50.157.189).

Stellar dynamics

The endpoint of collisionless relaxation of stellar systems remains a problem. The violent relaxation of 1-D systems does not tend to a stationary distribution function (44.151.002, A&A 228 344). The concept of the lowest accessible energy state was introduced into the problem of estimating the final state (45.151.063, 49.151.088, MN 244 260). Systems do not necessarily reach maximum entropy (44.151.008; see also 44.151.116 & 131). Irreversibility and mixing are discussed in 45.151.013.

Flattened isochrone models (oblate or prolate) were constructed (MN 244 111; see also 45.151.014). Solutions are given for the stellar hydrodynamical equations for Eddington systems (49.151.020). Numerical methods for constructing distribution functions for particular systems are discussed in 49.151.010.

It is possible for collisionless galaxies to be in an oscillatory state: see 46.151.003, 49.151.089, 50.151. 015 & 113.

Numerical techniques

Spectacular advances have been made in simulating collapse and interactions of galaxies. In tree codes, the computation time for the force calculation in N-body systems scales like N logN (44.151.030, 49. 151.031, 50.151.149). Smoothed particle hydrodynamics has also been included (49.151.032). New techniques for handling stability problems (MN 242 576) and highly clustered collisionless systems (MN 242 505) were developed. Highly parallel computers are in use for simulations (49.151.042). A quadratic programming technique was devised for constructing distribution functions for gravitating systems in the presence of observational constraints (50.151.122).

4. Groups and Clusters of Galaxies
(H.Quintana)

Studies of the large scale structure of the galaxy clustering reveal ever larger features and ongoing surveys have not yet reached the scale length for galaxy homogeneity. In the last three years the presence of voids and long coherent structures up to 200 Mpc in length have been confirmed. The discovery of large scale streaming motions has revealed another type of signature in the clustering of galaxies pointing to early conditions. The spatial and velocity characteristic of the clustering contain the information needed to build and test theories of galaxy formation. Particularly, the spatial distribution of rich clusters provides, at present, the most powerful evidence for large scale structure in the universe. Its correlation function seem to provide the most stringent test for clustering theories. Work in these topics has been plentiful and is the cause for a renewed interest, as the search for dark matter and efforts to evaluate biasing effects. An additional factor has been the discovery of luminous arcs due to gravitational lensing of background galaxies. The cosmological aspects of the galaxy clustering are covered in the Report of Commission 47.

Several conferences and workshops have been held: Large-Scale Structure and Motions in the Universe, ed Mezzetti + (Reidel 1988), Large-Scale Structures in the Universe Observational and Analytical Methods, Workshop, Bad Honnef FRG, 9-12 Dec 1987, ed Seitter + (Springer 1988); Cooling Flows in Clusters and Galaxies, NATO Workshop, Cambridge UK, 22-26 June 1987, ed Fabian (Kluwer 1988/cited here: Cooling Flows); Large-Scale Motions in the Universe, A Vatican Study Week, ed Rubin and Coyne (Princeton 1988/here: Vatican); The Minnesota Lectures on Clusters of Galaxies and Large-Scale Structure, ed Dickey (ASP Conf.Ser 5, 1988/here: Minnesota); The Epoch of Galaxy Formation, ed Frenk (Kluwer 1989); Clusters of Galaxies, STScI Workshop 15-17 May 1989, ed Oegerle + (Cambridge 1990/here: Cluster Galaxies); Dynamics and Interactions of Galaxies, Heidelberg FRG, 29 May-2 June 1989, ed Wielen (Springer 1990/here:

Interacting Galaxies); Workshop on Large-Scale Structures and Peculiar Motions in the Universe, Rio de Janeiro 1989; Paired and Interacting Galaxies, IAU Coll 124, Tuscaloosa USA, Dec 1989, ed Sulentic (NASA 1991); Superclusters and Clusters of Galaxies and Environmental Effects, Workshop, Sesto-Moso Italy, 2-5 July 1990, ed Giuricin + (in press).

Highlights of the last three years were the long-awaited publication of the southern extension of the Abell catalog (Abell + ApJ Suppl 70,1), the discovery of luminous arcs, confirmation of the streaming motion towards the Hydra-Centaurus region which may provide new constraints on theories of clustering, the standard operation of fiber spectrographs at large telescopes measuring hundreds of redshifts per night (with prospects for a ten-fold increase in the next years) and the widespread use of redshift-independent distance estimates permitting a 3-dimensional mapping of the nearby universe. X-ray information is crucial to the understanding of clusters and even when limited observations were made, reprocessing of Einstein data and analysis of samples have shown key results, such as the prevalence of cooling flows. ROSAT promises a complete flux limited all-sky survey of clusters less than a year ahead.

I. The Local Group (B.Binggeli)

Two new LG dwarf members have been detected: an irregular system in Camelopardalis at D ~ 0.8 Mpc (Hoessel+ PASP 100, 680), and a dwarf spheroidal in Sextans at D ~ 85 kpc (Irwin+ MN 244, 16p). Twenty years after their discovery the And dwarf spheroidals are finally observed (Mould + ApJ 354, 438). The LG distance scale is steadily improving, mostly due to new, CCD-based observations of Cepheids and RR Lyrae stars (ASP 100y Symp. on distance scale, reviews by Mould therein, and van den Bergh AA Rev 1, 111; Saha + AJ 100, 108; Freedman + ApJ in press).

Peebles + (ApJ 345, 108) worked out a model for the formation of the LG by gravitational accretion of matter onto two seed masses (to become M31+Galaxy). The kinematics of the outer LG members are reasonably well reproduced. The same holds for a different but related approach by Peebles (ApJ 344, L53; 362, 1), in which the single galaxy orbits are traced back in time by a least-action solution. The transverse velocity of M31 is predicted to be ~ 110 km/s. This is in conflict with Raychaudhury's + (MN 240, 195) value of 38 km/s which is based on the tides and torques exerted on the M31/Galaxy system by all galaxies closer than 10 Mpc. However, all this would be questioned if McCall's (AJ 97, 1341) claim were correct that the heavily reddened spiral IC 342 is nearly as luminous as the Galaxy and only 1.8 times farther away than M31. If true, we might live in a quartet of giant galaxies defined by the Galaxy, M31, IC 342, and Maffei 1.

II. Groups

Groups are important as a test bed to theories of galaxy formation, with different conditions than rich clusters, useful to differentiate between properties of galaxies at the time of formation and properties that develop during subsequent evolution. It is important to establish how much of the galaxies properties depend on environmental conditions. The same processes supposed to affect galaxies in clusters could be operating to diverse levels in groups: galaxy encounters to virialize orbits, collisional stripping and mergers, dynamical friction and tidal stripping from the mean background. The usual methods to investigate these complex effects are by numerical simulations. However, few experiments have been done recently: Barnes (Nature 338, 123), Mamon (ApJ 321, 622 and IAU Coll 124). Simulations tend to confirm early qualitative results in compact groups, suggesting an instability to galaxy merging in a rather short time, dependent on the amount and distribution of the dark matter, DM. If this end point were common to many different parameters, most groups must be young structures, still away from equilibrium.

Groups of faint members surrounding dominant dumbbells (db) have unusually large velocity dispersions and M/L ratios (de Souza + AJ 99, 1065; Quintana IAU Coll 124). The CFA redshift surveys have generated lists of groups: Ramella + (ApJ 344, 57), Maia + (ApJ Suppl 69, 809). Correlation functions have been determined by Ramella + (ApJ 353, 51), Nolthenius " (MN 225, 505) and others. Median velocity dispersion is 228 km/s and blue M/L is 178h (Hubble constant H=100h km/s/Mpc). A smooth variation of properties from groups to clusters was found. Maia + (ApJ 352, 457) claim that basically all the southern groups are loose, interpreted as been very young, with tidal interactions not important and not yet in equilibrium. Different are the conclusions for compact groups, reviewed by White (Interacting Galaxies p 380). Hickson + (ApJ Suppl 70, 687) obtained CCD photometry and morphological classifications of the sample of 100 groups, and with coworkers analyzed their enhanced activity and IR emission. Morphologies were found more strongly correlated with velocity dispersions (Hickson + ApJ 331, 64) than in loose groups, suggesting that galaxy morphologies were set in early phases of collapse. Rubin (Vatican, p 541) and Whitmore (Cluster Galaxies p 141) reviewed the properties of spirals in groups and clusters.

III. Nearby clusters (Virgo, Fornax)

The all-sky ACO catalog (Abell + cited) contains 4073 rich clusters. In spite of care for consistency, visual inspection is fraught with subjective factors. Both ACO and Quintana + (ApSpSc in press), on catalog work on a restricted sample, join others to insist on the need to use machine surveys and objective criteria for object identification. Such projects are underway (COSMOS and APM machines, UK, and APS in the USA).

Much work has been devoted to Virgo, Fornax and nearby clusters and the determination of redshift-independent distances. Sandage (Cluster Galaxies p 201) reviewed galaxies in those clusters. Haynes (Cluster Galaxies p 177) and Whitmore (cited) summarized cluster ambient effects on galaxies. Gas deficiency and falling rotation curves of spirals are among the most important. Several papers deal with the large dwarf and irregular population (Gallagher + AJ 98, 806). Most Virgo Magellanic and dwarf irregulars are optically similar to field galaxies, with differences usually interpreted as gas deficiency. Puzzling are the properties of red amorphous or peculiar E/S0 galaxies (Hoffman + ApJ 324, 75; 339, 812). APM results challenge the surface-brightness/magnitude relation for dwarfs as due to selection effects (Caldwell AJ 94, 1116; Caldwell + AJ 94, 1126; Cawson + MN 224, 557; Phillipps + MN 229, 505; Davies + MN 231, 69P; 292, 371). Ferguson (AJ 98, 367), presented an extensive catalog in Fornax, for which a core radius of 0.7 deg. was derived. The LM is analyzed in Ferguson + (AJ 96, 1520), who claimed APM results were due to the use of (not good scale) Schmidt plates for classification.

Dwarf E's have been used as distance indicators to the Virgo, Fornax and Centaurus clusters (Bothun + AJ 98, 1542). Results are in agreement with IR Tully-Fisher distances, with smaller errors (Aaronson + ApJ 338, 654). Centaurus was not found separated in two clusters, contrary to claims by Lucey + (MN 231, 15), though all dE's could only belong to the CEN30 cloud. For the Virgo cluster a large number of distance determinations has become available: globular clusters (Harris 50.160.045), novae (Pritchet + ApJ 318, 507; Sandage + ApJ 328, 1; Cappacioli + ApJ 350, 110), supernovae (Tammann + AA 236, 9), the D_n-σ relation (Dressler + ApJ 313, 42), 21cm-line widths (Kraan-Korteweg + ApJ 331, 620; Fouqué + ApJ 349, 1), the relative size of our Galaxy and M31 compared to the largest Virgo spirals (van der Kruit AA 157, 230), and the luminosity fluctuation method (Tonry + ApJ in press) all obtain a distance of ~ 20-22 Mpc (for reviews see Tammann 50.160.048 and van den Bergh AA Rev.1, 111). This with the "cosmic" expansion velocity of the cluster of 1144±18 (i.e. freed from all local streaming effects; Sandage + ApJ in press) gives H_o = 50-55. However, the Hβ-σ relation of HII regions (Melnik + MN 235, 297), the luminosity function of planetary nebulae (Jacoby + ApJ in press), and - according to some authors - 21cm-line widths (Tully Nature 334, 209; Pierce + ApJ 330, 579) give a Virgo distance of ~ 15 Mpc and a correspondingly larger value of H_O. - Surprisingly low values of the infall velocity towards Virgo have been determined (~ 110 km s^{-1} by Faber + Vatican p 115; 168±50 km s^{-1} by Sandage + ApJ in press).

IV. Abell and medium distance clusters

The cluster-cluster correlation function is much stronger than the galaxy-galaxy correlation (amplitude 20 times higher); in principle a more sensitive test for theories of galaxy and cluster formation (Frenk + ApJ 351, 10; White, Rio Workshop). This has been derived from a sample of 102 nearby clusters. Given its importance, completion of wider and more objective samples should have high priority for future work. Galaxy clusters are peaks in the 3-d galaxy distributions but cluster catalogs are defined as peaks in 2-d, which could have strong systematic effects (see Comm. 47 report for more on this topic).

The Hydra-Centaurus region has conceited much attention because of the large-scale flows, as shown by: Dressler + ApJ 313, 42; Lynden-Bell + ApJ 326, 19; Lucey + MN 235, 1177; MN 231, 15; Faber + Vatican p 115; Aaronson + ApJ 338, 654; Burstein + ApJ 354, 18; Dressler + ApJ 354, 13; Lucey + 1990 Preprint; Dressler + ApJ 354, L45; Raychaudhury +(preprint). Distance measurements to E, S0 and Sp galaxies confirm that the peculiar velocity field rises to 1000 km/s at 3000 km/s redshift, decreasing to near zero by 4000 km/s, with hints for a sign reversal farther out. The Great Attractor, GA, would be located at 45 Mpc, perturbing the Hubble flow over a 100 Mpc region. However a model based on the distribution of IRAS galaxies is claimed to provide a better fit to the data without requiring a different mass distribution than the galaxies (Yahil and Strauss + Vatican p 219 and p 256). Bothun + (ApJ 353, 344) noted the problem of incomplete samples when trying to derive distances. Using simulations they investigate the observed field that arises when incompletely sampling a very large distant structure: even when peculiar velocities were real, their interpretation is highly ambiguous and does not necessarily imply streaming toward any distant mass point. Opposite the GA direction, towards the Perseus-Pisces Supercluster, the peculiar velocity field continues (Willick ApJ 351, L5), with a motion towards us of -450 km/s, similar in magnitude and direction to the one in the south. If this motion is just an extension of the motion towards Hydra-Centaurus, then the coherence length is doubled to some 10000 km/s in depth. The present GA model predicts a peculiar field of only -160 km/s at the Perseus-Pisces position.

Much work has been done on the analysis of subclustering in clusters, because its degree has consequences for theories of galaxy and cluster formation. It is fairly urgent that some consensus is reached. So far, there is agreement of about 30 studies; there is no agreement on measurement criteria, degree and presence of subclustering of individual objects (West + ApJ 350, 36). There have been claims of substructure in many clusters, even for Coma (Fitchett + ApJ 317, 653; Fitchett + ApJ 335, 18; Mellier + AA 199, 67). In contrast, West + (ApJ 327, 1) found little subclustering on the same sample (Dressler 1980), used by Geller + (1982) and other workers, and claim that using only the projected galaxy distribution is fraught with great uncertainties. Several studies have stressed analysis of the velocity field, where deviations from a Gaussian distribution, which characterize relaxed clusters, can be considered signs for substructures. Dressler + (AJ 95, 284) used a statistics that simultaneously consider positions and velocities. They found similar proportions of subclustering, but in different clusters. West + (ApJ 350, 36) remarked all subclustering is present only beyond a projected radial distance of 1 Mpc, indicating that the main bodies of clusters would be relaxed. Substructures in the outer parts should be quite common due to superposition of more or less rich groups. It should be noted that the claimed substructure in Coma is not borne out by the smooth, regular x-ray image. Important for clustering theory tests are the alignments of clusters and of their dominant galaxies (Struble ApJ 323, 468 and AJ 99, 743; Tucker + AJ 95, 298) and with nearby clusters (Rhee + AA 183, 217; Flin MN 228, 941) and general galaxy distribution (Muriel AJ 98, 1995). However, Ulmer + (ApJ 338, 711) found no alignments between neighboring clusters, based on x-ray (McMillan + ApJ Suppl 70, 723) and optical images. West + (ApJ 336, 46) argue that observed alignments of the Shane-Wirtanen counts with Abell clusters (Lambas + AJ 95, 975 and 996) are in conflict with CDM models.

Other controversial substructures are the existence of central cusps around cD galaxies. Merrit (Minnesota p 175), Lauer (ApJ 325, 49 and Interacting Galaxies p 406), Tremaine (Interacting Galaxies p 394) and Richstone (Cluster Galaxies p 231) have estimated the dynamical evolution at the centers of clusters. Results are dependent on the DM distribution, with early growth of cD's occurring in subclusters, continuing at a slower pace later on. Density cusps, quite common in cD clusters, were studied by Merrifield + (AJ 98, 351; preprint) by stacking CCD images of clusters and a kinematical analysis. The distribution of the density is well described by an exponential profile, scale 100 h^{-1} kpc, characteristic of effects of dynamical friction, suggesting a significant role in their evolution. However, there is no evidence for the then expected luminosity segregation and statistical tests of the kinematics show only 5-20 galaxies within 20 kpc can form part of a low-velocity satellite cD population. Bower + (MN 220, 122 and Cooling Flows p 115) obtained velocities in A2029 and found that cD neighbors had the cluster dispersion, with no signs of dynamical friction. Similar results have been reported by the extensive redshift surveys of Hill + (ApJ 332, L23) and Sharpless + (MN 231, 479). However, Bothun + (ApJ 335, 617), Bothun + (ApJ 360, 436) and Quintana + (AJ 100, in press) discovered clusters where the cD's satellites have dispersion of 200 km/s or less: A2589, A1991, A496 and marginally A2107 and A2593, all clusters with cD's at rest with respect to the mean field. It appears that these cluster cD's have bound populations while cD's away from the mean velocity do not. Surprisingly, there may be bounded populations away from a cD galaxy, as A2634 suggests (Bothun + cited). Therefore, the exact role of dynamical friction is unclear for the growth of cD galaxies. An alternative view for cD formation is proposed by Tremaine (Interacting Galaxies p 394) as due to the merging of the central galaxies from two merging clusters, via the production of a dumb-bell galaxy. In fact, there is a large population of db's at the centers of clusters (and groups), which sometimes show large relative velocities between components (Valentijn + AA 206, 27).

Masses of clusters have been determined from available data by Zabludoff + (ApJ Suppl 74, 1), while Regos + (AJ 98, 755), Ostriker + (AJ 96, 1775) and Kaiser (MN 227, 1) discussed infall patterns and models. The Coma mass has been reanalyzed by Merritt (ApJ 313, 121), The + (AJ 92, 1248), Cowie + (ApJ 317, 593) and Hughes + (ApJ 329, 82; ApJ 337, 21) who combined models for the optical and x-ray data, obtaining $M/L=165$ (±25)h solar. The + (AJ 99, 7) discarded the possibility that the Coma cluster could be dominated by a binary formed by the two giant E's. Dynamical analysis were published for A2256 (Fabricant + ApJ 336, 77), A2670 (Sharples + MN 231, 479) A1689 (Gudehus ApJ 340, 661), among others. Schombert + (AJ 98, 1999) rejected the binary-rich nature of A2244, while Oegerle + (AJ 91, 4; AJ 93, 519; AJ 98, 1523) derived luminosity functions for several nearby clusters based on photographic plates, confirming the small dispersion of L^* and the flattening of the faint end slope in some clusters. Bell + (ApJ Suppl 70, 139) measured photometric properties in DC 1842-63 galaxies, Porter + (preprint) in 175 brightest E's. Vigroux + (AJ 98, 2044) reported an unusual Butcher-Oemler effect in a nearby cluster and Pence + (preprint) a ring galaxy in A2199. Theoretical calculations of strong tidal interactions were given by Glynn (ApJ 348, 515) and Pelletier + (preprint) provided data on that topic. The ratios between luminosity x-ray emitting gas and virial masses was reviewed by Forman + (Cluster Galaxies p 257). Edge + (preprint) found evidence for evolution in the x-ray luminosity functions from a flux-limited sample.

X-ray observations show the conditions leading to cooling flows while theoretical models indicate cooling times are less than a Hubble time (Forman in Cooling Flows p 17; While + ApJ 318, 621 and ApJ 335, 688). Estimated flows reach up to 500 M_O/yr (Arnaud in Cooling Flows p 31). However, deposition of this mass at the cluster center, where a massive galaxy is always located, has been elusive to detect (O'Connell + AJ 98, 180; McNamara + AJ 98, 2018; Mathews AJ 95, 1047; Fabian in Hot Thin Plasmas in Astrophysics). Emission nebulae, HI observations, colors as probes of high mass stars, CO detections, all have given orders of magnitude smaller masses than what should be deposited by the flows (Heckman + ApJ 338, 48; Johnstone + MN 224, 75; Jaffe + in Cooling Flows p 145; Jaffe AA 171, 378; Bergman + AJ 96, 455; Lazareff + ApJ 336, L13; Shields + ApJ 353, L7). Possible mechanisms for heating the gas and/or inhibit the size of the flows have been proposed, but the matter is open (Meiksin ApJ 334, 59; Gaetz ApJ 345, 666; Pringle MN 239, 479; Just + ApJ 354, 400; Soker + ApJ 348, 73; David + ApJ 337, 97; Bergman + ApJ 326, 439 and preprint). Another solution is to consider unsteady flows, where the mass accretion rate decreases to the cluster center: enough to agree with observations (Chevalier ApJ 318, 66 and ApJ 329, 16; Bertschinger in Cooling Flows p 337). Still another possibility is cluster potential evolution, which will induce temperature changes in the gas (Meiksin ApJ 352, 466). The presence of intracluster magnetic fields has now been measured by Faraday rotation (Vallee + Ap Lett Comm 25, 181; Dreher + ApJ 316, 611; Hennessy + preprint; Kato + Nature 329, 22), and observations of the radio halo giving direct measurement of the cluster magnetic field were reported by Kim + (ApJ 355, 29) and Vallee (AJ 99, 459). VLA observations of Abell clusters have been done by Zhao + (AJ 98, 64) and Moffet + (AJ 98, 1148), while Burns (AJ 99, 14) observed central galaxies. Dust in clusters was observed by Dwek + (ApJ 350, 104), extinction by Boyle + (MN 231, 897), IR from central galaxies by Bergman + (ApJ 351, 406).

V. Distant clusters

The subject, on observational and theoretical grounds, is on a very preliminary stage. Since structures of cluster masses are just forming in most theories, they are good measures of the perturbation spectrum at those masses (Peebles + preprint). However, the inner, denser regions of clusters should be quite old, providing objects and galaxy environments that can be studied back to z=1, as stressed by Gunn (Cluster Galaxies p 341), who discusses catalogs in progress. Observations showing an increasing population with redshifts of AGN, star forming and postburst galaxies were carried out by Mellier and Gunn + (in Towards Understanding Galaxies at High Redshifts), Soucail + (AA Suppl 73, 471), Lilly (MN 229, 573), Newberry + (ApJ 335, 1 and ApJ 350, 585), and discussed by Gunn (Galaxy Formation) and Dressler + (ASP Conf Series vol 10). Active galaxies have peculiar spatial and velocity distributions, avoiding central regions and having significantly higher dispersions. It would seem that galaxies go once through the active phase as they plunge the first time into the intracluster gas. In work by Dressler and Gunn galaxies at the centers of clusters appear very red, possibly indicating an early formation or a different evolutionary history.

Clusters at redshifts 0.25-0.35 have been found to be excellent gravitational lenses producing luminous arcs (Lynds + ApJ 336, 1; Soucail + AA 184, L7; 191, L19; Mellier + AA 199, 13; Fort + AA 200, L17; Lavery + ApJ 329, L21; Giraud ApJ 334, L69; Wamsganns + ApJ 337, L73). Models have been presented by Blanford + (Phys Rev A 38, 4028), Kovner + (ApJ 337, 644), Grossman + (ApJ 324, L37; ApJ 344, 637), Hammer + (preprint), Bergman + (ApJ 350, 23) and others. Strong constraints on the distribution of DM can be worked out for specific models, notably in the core regions, as given for example by the overall alignments of background galaxies (Tyson + ApJ 349, L1).

5. Quasars and related topics

(P.Véron and M.-P.Véron-Cetty)

I. Symposia, conferences and workshops

The proceedings of twelve meetings closely related to QSOs have been published in the last three years: *Supermassive black holes* (Fairfax, Virginia, October 1986), *Super- luminal radiosources* (Big Bear Solar Observatory, California, October 1986), *QSO absorption lines: probing the Universe* (Baltimore, May 1987), *Active galactic nuclei* (Atlanta, Georgia, October 1987), *Optical surveys for quasars* (Tucson, Arizona, January 1988),*Hot spots in extragalactic radiosources* (Tegernsee, F.R.G., February 1988), *Gravitational lenses* (Cambridge, Massachusetts, June 1988), *Active galactic nuclei* (134^{th} symposium of the IAU, Santa Cruz, California, August 1988), *BL Lac objects* (Como, Italy, September 1988), *Extranuclear activity in galaxies* (Garching, F.R.G., May 1989) *Cosmology and gravitational lensing* (Tegernsee, F.R.G., June 1989) and *Parsec-scale radiojets* (NRAO, New Mexico, October 1989). One other meeting is partly devoted to quasars: *The impact of VLBI on astrophysics and geophysics* (129th symposium of the IAU, Cambridge, Massachusetts, May 1987).

II. Catalogues, surveys and cosmic evolution

An addition to the Hewitt and Burbidge quasi-stellar objects catalogue (Astrophys. J.Suppl.69, 1) and the fourth edition of the Véron and Véron-Cetty catalogue of quasars and active nuclei (ESO Scientific report No 7) have been published.

Three major quasar surveys have been published; one is an ultraviolet-excess survey (MN **243**, 1), the two others are objective-prism surveys (AJ **98**, 1959; AJ **100**, 47); two more reach very faint magnitudes (B ~ 21.5-22.0) (MN **232**, 111; PASP **101**, 351; ApJ **325**, 92). Two surveys especially devised to find high redshift quasars have turned out to be quite successful as 10 quasars with z > 4 have been found, the largest being z = 4.73 (Nature **325**, 131; Nature **330**, 453; ApJ **321**, L7; AJ **98**, 1507, 1951). An additional z > 4 quasar has been discovered serendipitously (ApJ **328**, L29).

The shape of the quasar luminosity function and their cosmic evolution have been studied (ApJ **325**, 92, 103; ApJ **357**, 326; MN **235**, 935; AJ **97**, 336); the possibility that high-redshift quasars are hidden by dusty galaxies has been investigated (ApJ **353**, 411).

III. Emission spectrum and central engine

The multiwavelength energy distribution (0.1-10 mm) of quasars (excluding blazars) can be fitted with accretion disk models combined with a power law and a Balmer continuum plus FeII emission; it is found that Seyfert 1 galaxies are accreting at quite low rates (a few percent of their Eddington luminosity) while luminous quasars are accreting at rates close to their Eddington limits; the black hole masses of Seyfert galaxies ($10^{7.5}$-$10^{8.5}$ M_O) are in general smaller (by less than a factor of ten) than those in luminous quasars (10^8-$10^{9.5}$ M_O) (ApJ **329**, L11; ApJ **346**, 68; AA **209**, 27). The mass of the black holes in individual low luminosity quasars or Seyfert 1 galaxies has been estimated; they are in the range 10^7-8.10^8 M_O (AA **198**, 16; AA **200**, 17; ApJ **325**, 114; ApJ **345**, 637; ApJ **358**, L37), although masses as low as 10^6 M_O have been measured (ApJ **353**, 438). "Dead quasars" (low accretion rate) may sit in the nucleus of nearby galaxies (Science **247**, 817; ApJ **340**, L5). The infrared continuum is produced by warm dust heated by the quasar nucleus (ApJ **353**, 419; ApJ **354**, 148); the soft X-ray continuum (0.1-1 keV) could be thermal emission from the hot innermost region of the accretion disk (MN **233**, 475; MN **238**, 957; AA **231**, L1).

The complete structure of the nuclear engine of active galactic nuclei has been the object of several detailed investigations (MN **236**, 21, 153; ApJ **337**, 236; ApJ **344**, 115; ApJ **347**, 640; ApJ **352**, 58; ApJ **354**, 446; AA **229**, 313; AA **233**, 40, 53).

A number of ultraluminous infrared active galaxies with bolometric luminosities greater than 10^{12} L_O have been discovered (ApJ **328**, 161, L35; ApJ **343**, 672; ApJ **359**, 291); evidence of enormous gas supplies in these objects is provided by the detection of CO (~ 10^{10} M_O of H_2) (ApJ **325**, 74; AA **213**, L5). The proportion of interacting systems among them is very high, indicating that galaxy interaction is a causal factor in luminous IR activity (MN **240**, 329, 349; AJ **96**, 1575). Nuclear activity in galaxies may indeed be induced by the tidal perturbation of companion galaxies (ApJ **328**, 103).

Lobe dominated quasars contain normal radioquiet quasars and unrelated sources of radioemission (ApJ **325**, L21; ApJ **353**, 416). Radioloud and radioquiet quasars form two distinct populations; the distinction between them cannot be explained simply by the effects of geometry and relativistic beaming for objects having a fixed ratio of intrinsic radio and optical luminosities (AJ **98**, 1195). The environments of radioloud and radioquiet quasars also suggest that they are intrinsically different populations without evolutionary connection (ApJ **348**, 38).

Blazars are characterized by high optical polarization, strong variability and a compact flat spectrum radioemission (AA **205**, 86). Although most highly polarized quasars are blazars, the polarization of OI 287 has been shown to be due to scattering (ApJ **328**, 569; ApJ **331**, 325, 332). The continuum of blazars from millimeter to soft X-ray wavelengths is due to incoherent synchrotron emission in a single component (MN **235**, 787; AJ **95**, 307) which varies on a time scale of days or even hours (Nature **337**, 627; AA **229**, 389; ApJ **336**, L9); the centimeter emission can be attributed to a separate, more slowly varying component (ApJ **331**, 746; ApJ **340**, 129). The global energy budget of blazars is dominated by infrared emission from 1 to 100 mm, and the bolometric luminosities range from 10^9 to 10^{14} L_O (AJ **95**, 307).

Blazars have an amplitude of optical variability of one magnitude or more; a large fraction of all quasars are also variable, but with an amplitude of a few tenths of magnitude (AJ **95**, 374; AJ **96**, 1215). The broad emission lines of blazars are rapidly variable (MN **239**, 75).

The explanation of superluminal motion, another characteristic property of blazars (AA **206**, 245), in terms of the relativistic beaming model has become fairly widely accepted (AA **228**, 17; AA **230**, 271; ApJ **328**, 114; ApJ **340**, 117; ApJ **348**, 135; ApJ **352**, 81; ApJ **359**, 296; AJ **97**, 1550; MN **245**, 408; Nature **331**, 149). An extreme example is AO 0235+164 which has an estimated jet's bulk Lorentz factor G ≥ 25 (ApJ **326**, 668).

New blazars have been discovered either through their radioemission (AJ **99**, 1; AA **205**, 86; AA Suppl.**76**, 145), their X-ray emission (ApJ **348**, 141; ApJ **350**, 578; ApJ Suppl. **72**, 567) or their optical polarization (ApJ **333**, 666; ApJ **354**, 124). Weak blazarlike activity has been detected in 3C273 (ApJ **347**, 96; AJ **99**, 769; Nature **335**, 330).

IV. The unified scheme

The idea that there is only one kind of active galactic nucleus (PASP **99**, 309) is making progress. The radio, optical, IR and X-ray properties of blazars, lobe dominated radio quasars and powerful radiogalaxies suggest unification of these sources, the orientation of the radioaxis, coupled with a central obscuring torus, being the discriminator; an opening half-angle of ~ 45° for the torus is suggested. In this scheme, blazars are QSOs beamed toward the observer (ApJ **336**, 606; ApJ **343**, 672; AA **228**, 17; MN **224**, 257).

There is no difference between the local environments of radio-loud QSOs and powerful radiogalaxies in term of galaxy density or the shape of the companion galaxy luminosity function (ApJ **348**, 38); moreover, radioquasar host galaxies and radiogalaxies have the same absolute magnitude, lending support for the unification of the two (AA **236**, 69).

The luminosity of [OIII] 5007 Å in radioloud quasars and narrow-line radiogalaxies supports this model if the emission line region in radiogalaxies suffer an extinction of at least two magnitudes (Nature **338**, 485; Nature **343**, 43). Some objects, however, do not fit easily into this model, as for instance the giant, superluminal quasar 4C 34.47 (ApJ **336**, 601), the lobe dominated radiogalaxy 3C 390.3 in which superluminal motion may have been detected (AA **192**, 53) or the superluminal steep-spectrum radio source 3C 216 (ApJ **329**, L51). A few radiosources which have a weak core and a single radiolobe have been discovered; they are not easily explained in the framework of the relativistic beaming model (Nature **339**, 286; J.Astrophys.Astr.**10**, 203).

Similarly BL Lac objects could be weak radiogalaxies dominated by beamed emission from a relativistic jet aligned with the line of sight (ApJ **356**, 75); however radio jets in low luminosity radio-galaxies seem not to be relativistic (ApJ **354**, 98).

Spectropolarimetric study of Seyfert 2 galaxies has shown that a significant fraction of them are in reality Seyfert 1 galaxies in which the nuclei are hidden from direct view by an obscuring geometrically and optically thick torus (ApJ **340**, 190; ApJ **355**, 456). The radioproperties of Seyfert 1 and 2 galaxies are the same which supports the view that Sey-fert 2 are obscured Seyfert 1 (ApJ Suppl.**72**, 551).

The gas in the torus is not smoothly distributed; most of its mass must be gathered into clouds. Clouds of particularly low momentum are captured by the central object. Cooling of the clouds is accomplished primarily by radiation of near-IR H_2 lines and far-IR CO lines (ApJ **329**, 702; ApJ **347**, 179; ApJ **352**, L33). The discovery of H_2 and CO emissions in several Seyfert 1 galaxies, radiogalaxies and quasars suggests the existence of a molecular torus in these objects (ApJ **340**, L9; ApJ **352**, 433, ApJ **354**, 158). The torus may be responsible for the X-ray absorption observed in some Seyfert 2 galaxies (MN **240**, 833).

V. QSO's as probes of matter at high redshift

Voids have been searched for in the Lyman a forest; Ly a clouds at z ~ 2-4 seem to be much more uniformly distributed than are galaxies at z ~ 0 (ApJ **327**, L35; ApJ **345**, 39, 52). The number density of Ly a clouds drops dramatically with time between redshifts of 5 and 3 (AJ **98**, 1507, 1951); however, the Lyman-limit absorption systems show no evolution between z = 0.7 and 3.6 (ApJ **332**, 96, ApJ Suppl.**69**, 703). The distribution of MgII systems is consistent with a constant comoving density between z = 0.2 and 2.1 (ApJ **334**, 22; ApJ Suppl.**69**, 703; AA **231**, 309). The distribution of CIV absorbers shows a gradual decline for z > 2 (ApJ Suppl.**68**, 539; ApJ Suppl.**72**, 1). These observations imply that the heavy element composition in the outer parts of galaxies, which are most probably responsible for the CIV, MgII and Lyman limit absorptions in QSO's, reached a saturation value at z ~ 1 and that, before this, the enrichment proceeded roughly linearly with time for 2.5 billion years (ApJ **333**, L5). Low metal abundances have been measured in absorption systems at z = 1.78, 2.31 and 2.97 (ApJ **335**, 584; ApJ **348**, 48; ApJ **351**, 364).

VI. Gravitational lenses

Four new gravitational lenses have been discovered (Nature **334**, 325; AA **198**, 49; ApJ **338**, L1; ApJ **346**, L61), as well as two binary quasars (ApJ **321**, L17; ApJ **330**, 184). Two candidate lensed quasars with subarcsecond separations have been found (AJ **98**, 1188). Spectroscopic differences in the spectra of the two components of Q 2345+007 suggest that it is a pair of quasars rather than a lensed quasar (AJ **99**, 1693); however one of the component has been resolved confirming that it is indeed a lensed object (ApJ **325**, 644). It has been suggested that some BL Lac objects are distant violently variable quasars lensed by intervening galaxies (Nature **344**, 45; Nature **345**, 692; MN **243**, 192). Gravitational microlensing has been predicted (ApJ **352**, 407; Nature **338**, 745) and possibly detected (AJ **98**, 1989; ApJ **358**, L33) in the quadruple quasar Q2237+0305; microlensing may (AA **198**, L13; AA **206**, L30, AA **224**, L27) or may not (AA **206**, L8; ApJ **347**, 701) explain the rapid, large amplitude, variability of some BL Lac objects. Two Einstein ring images of a radio lobe have been discovered (Nature **333**, 537; Nature **344**, 43; MN **238**, 43; AJ **97**, 1283).

It has been suggested that distant quasars ar associated with foreground galaxies (Nature 336, 358; AA **204**, 73; AA **222**, 45); it does not seem to be possible to explain this effect by lensing (ApJ **339**, L53; ApJ **341**, L1; AA **204**, L8; AA **221**, 221).

The time delay between the optical light-curve of the two components of the lensed quasar 0957+56 is equal to 415 days (AA **215**, 1); the lens mass is $6x10^{11}$ M_O (ApJ **357**, 309).

6. Extragalactic Research in USSR
(E.Ye.Khachikian)

Abbreviations:

Af	Astrofizika
AZ	Astron.Uhurnal
LAZ	Letters to AZ (Pis'ma)
AC	Astron.Circ.
CrAO	Izvestia Crimean Astrophys.Obs.
SAO	Communic.Special Astrophys.Obs.
BAO	Communic.Byurakan Astrophys.Obs.
AAp	Astron. and Astrophys.
IAU	Pros.IAU workshop
Sy	Seyfert Galaxies

I. Surveys and lists of galaxies

Stepanian+ (Af, 29, 247) continue the second Byurakan Spectral Survey (SBS). Markarian+ (SAO, 62, 5) prepared the full catalogue of galaxies from the First Byurakan Spectral Survey (FBS). Lipovetsky+ (SAO, 55, 5) published a catalogue of Sy's with 959 objects. Karachentseva and Sharina (SAO, 51, 5) published the catalogue of low surface brightness dwarf galaxies. Iskudarian (BAO, 61, 39, 46) composed the lists of probable and possible Irr galaxies. Karachentsev+ (AAp, 205, 377) prepared the list of all bright HII regions in M81 of Hα observations. The observations of Magellanic Clouds with the TTM X-ray telescope and the cosmic module KVANT on MIR station are carried out by Syunaev+ (LAZ, 16, 124). The results of UV observations of 19 galaxies from the space telescope ASTRON are presented by Merkulova+ (AZ, 67, 449). Malumian (AZ, 67, 33) discussed the results of radio observations of faint radio sources in RATAN-600. Karachentsev and Kopilov (IAU 130, 139) completed the survey of the redshifts of all galaxies with $m<18^m$ (315) in the Coma cluster region.

II. Active and star burst galaxies

Spectral observations of galaxies with UV excess from the Byurakan First and Second Survey were continued by Markarian+ (Af, 28, 27; 28, 476), Lipovetsky+ (Af, 31, 425; 29, 548) and for Kazarian objects by Kazarian (Af, 27, 399) Kazarian+ (Af, 28, 39). Spectral and optical variability of AGNs is observed and discussed by Shevchenko (Af, 28, 59), Terebiz+ (Af, 31, 75), Lutiy Raschimov (LAZ, 13, 973; 15, 205), Aslanov+ (LAZ, 15, 308), Doroshenko+ (LAZ, 15, 483), Lutiy+ (LAZ, 15, 519), Chuvaev Oknianskiy (AZ, 66, 1), Fronik, Fronik (AZ, 65, 478), Guseinov (AC, 1533, 1), Lutiy+ (AC, 1518, 4), Merkulova+ (KrAO, 77, 144), Erastova+ (Af, 32, 177). Spectrophotometric and photometric investigation of AGNs is carried out by Doroshenko (Af, 28, 5; 465, 233), Poliakova (AC, 1525, 3, Af, 28, 19), Reshetnikov (Af, 31, 49), Zasov, Neizvestnij (LAZ, 15, 963), Merkulova, Pronik (KrAO, 77, 135), Metik, Pronik (KrAO, 80, 76). Morphological investigation of AGNs carried out by Pronik (KrAO, 77, 126), Dubinov+ (LAZ, 16, 114) and subarcsec morphological investigation of AGNs - by Balega+ (LAZ, 14, 23). Zentsova (Af, 28, 505) investigated the slow jets in Sy's, the profiles of emission lines (AZ, 67, 463) and relation between star formation and gas flow from AGNs (AZ, 65, 190). Neizvestnij (AZ, 66, 520; 693) investigated the colours and luminosities of the host galaxies of AGNs. Illarionov and Romanov suggested dense star cluster as the source of activity in AGNs and QSOs (AZ, 65, 682). Zentsova (AZ, 64, 720) presented the relation between parameters of AGNs and evolution of Sy's. Barishev, Morozov (Af, 28, 111; 273), Komissarov (Af, 28, 261; 517), Zentsova (AC, 1537, 3) discussed the models for radio galaxies. The radio halo around Mrk 421 have been found by Malumian+ (AC, 1535, 9).

Komissarov (Af, 29, 345) discussed the morphology of radio galaxies. Ohanian presented (BAO, 61, 29) the results of radio observations of NGC 7714 (Mrk 538) and QSO 2333+019. Sholomitsky, Charugin (LAZ, 14, 483) discussed the results of decimeter radio observations of AGNs and QSOs. Makarov and Reshetnikov (LAZ, 16, 18) investigated the condensations in the jet of M87. The results of detailed spectrophotometrical and morphological investigations of the UV galaxies Mrk 297 (Burenkov, Af, 28, 47), Mrk 5, 307, 1118 (Burenkov+, Af, 29, 223, 541; 27, 409), Mrk 323 (Petrosian+, LAZ, 15, 1059), some Kazarian galaxies (Egiazarian and Khachikian, BAO, 60, 3, 13) are discussed. Asatrian and Petrosian (AC, 1536, 5) discussed the nature of the peculiar galaxy Mrk 314. The existence of double or multiple nuclei structure is indicated in 13 Markarian galaxies by Abranamian+ (Af, 31, 441) and Petrosian+ (IAU Symp.134, 445). The statistical study of Markarian galaxies in the optical radio and FIR ranges is carried out by Izotov and Izotova (Af, 30, 34; 312). The relation between FIR and optical properties of the 235 Markarian galaxies with thermal emission-like spectrum is examined by Khachikian+ (Af, 30, 324). The problem of the presence of UV galaxies in galaxy systems by Kazarian+ (Af, 28, 487), Egiazarian+ (BAO, 61, 53) is discussed. Petrosian published (Af, 28, 487) the list of Sy's in clusters of galaxies. Tovmassian and Akopian (BAO, 61, 32) found that the frequency manifestation of radio emission in SBc galaxies correlates with optical properties of nuclear activity of galaxies. Fridman (AC, 1533, 5) worked out the new theory of formation of double nuclei structure in galaxies. Petrosian+ (AAp, 212, 79) found that the SN frequency in Markarian galaxies does not differ significantly from that of normal galaxies.

III. QSOs and BL Lac objects

The space distribution of quasars, blusars and QSOs in relation to their spectral indices (Khodiachi, Af, 31, 87; AC, 1534, 1) and reality of their inhomogeneous redshift distribution (Krutevenko, Orlov, AC, 1541, 5) are discussed. Levshakov (Af, 29, 408), Levshakov+ (AZ, 64, 929), Afanasev+ (LAZ, 15, 195), Chernomordnik (AZ, 65, 695) investigated the absorption spectra of QSOs. Afanasev+ (AN, 310, 97) published the results of the QSO search in the field A88. Levshakov and Boltz (LAZ, 14, 1093) found molecular hydrogen-absorbing material at z=2.811 towards the quasar PKS 0528-250. Boltz (AZ, 66, 252) analyses by autocorrelation methods the absorption spectra of QSOs. Komberg (Af, 30, 399) proposed that double QSOs are real physical pairs. Zentsova (Af, 27, 499) discussed the nature of the emission in the nebulae surrounding QSOs . Bisnovatij-Kogan (LAZ, 13, 855) suggested that the structure and evolution of hydrogen-helium superstars are powered by the annihilation of barions at their collisions with magnetic monopoles. Afanasev+ (AN, 310, 187) presented some suggestions on the cosmological evolution of the quasar population. Belov+ (Af, 30, 7) investigated the variability of the radio and optical emission of BL Lac. Zentsova (AZ, 64, 1312) presented the results of the observations of X-ray absorption lines of BL Lac. Lipovetski (AZ, 66, 1132) made the search of spectral lines of BL Lac type objects. Hagen-Thorn and Marchenko (Af, 31, 231) proposed a method of components separation of Lacertides OQ530 and 0I090.4 and evolution of their redshifts.

IV. Structure and kinematics of galaxies

Sharov and Lutiy (AZ, 66, 241) constructed luminosity function of globular clusters in M31. The same authors (AZ, 65, 897) carried out the electrophotometrical investigation of the nuclei of galaxies of the Local System. Sharov and Alksnis (LAZ, 15, 885) discussed the possible novae in M31. Georgiev (LAZ, 14, 129; 806, 882) investigated the spiral structure of M31 in U colour. Getov and Georgiev (LAZ, 14, 811) presented the results of observations of low luminosity details in M81 and M82. Sakibov and Smirnov (AZ, 67, 472) reported about multicolour photometry of star formation regions in the galaxies NGC 2403, 2903, 4038/39, 5194 and kinematic of gas in the galaxies NGC 2903, 3031, 925 (AZ, 66, 921). Usovich (Af, 28, 510), Makarov+ (Af, 30, 15) Antonov and Zelezniak (Af, 29, 178; AZ, 65, 461), Afanasev and Kostiuk (Af, 29, 213), Zelezniak (AC, 1539, 9; 11) considered the problem of ringlike structures in spiral galaxies. The radio and optical properties of the central regions of spiral and elliptical galaxies was investigated by Malumian (Af, 15, 24); Tovmassian and Oganessian (BAO, 61, 3); Silchenko (LAZ, 15, 493), and Dzafarov and Zasov (AC, 1540, 1). The investigations concerning the disk structure of spiral galaxies are carried out by Afanasev+ (AAp, 213, L9); Osipkov and Kutuzov (Af, 27, 523); Gestrin and Kondorovich (LAZ, 13, 648); Zasov and Zotov (LAZ, 15, 210); Poliachenko (LAZ, 15, 890); Zasov and Dzafarov (AZ, 64, 900); Levi and Morozov (AZ, 64, 919); Krasheninikova+ (AAp, 213, 19); Starchenko and Shukurov (AAp, 214, 47); Baev+ (LAZ, 13, 964); Zasov and Fridman (AC, 1519, 2). Halo structure of spiral and elliptical galaxies was discussed by Suchkov (Af, 28, 279); Berman and Suchkov (Af, 30, 48); Gnatiuk and Krol (Af, 29, 511); Suchkov (AC, 1535, 7); Einasto and Haud (AAp, 223, 89; 95). The relation between Hubble type and dynamics and the luminosity of galaxies is examined by Maksimov and Sakibov (AC, 1520, 1), the mass to angular momentum relation by Mineva (AZ, 65, 702) and the relation of isolated galaxies and galaxies in pairs by Zasov and Rubsova (LAZ, 15, 118). Suchkov (LAZ, 15, 216) examined the optical and X-ray properties of elliptical galaxies. Volkov (Af, 32,

133) and Vereschagin (AZ, 66, 527) investigated the gas content of ellipticals. The orientation and shape of spiral and elliptical galaxies are discussed by Nikiforov (Af, 30, 336) and Fesenko (Af, 31, 467). Karachentseva+ (AN, 308, 247), Karachentsev+ (AN, 310, 199) and Karachentseva (LAZ, 16, 99) presented articles on the structure of low-surface brightness dwarf galaxies in the M81 group, about the isolated dwarf galaxy K23 and about the surroundings of dwarf galaxies. Pasha (LAZ, 14, 195) discussed the problem of satellites of galaxies. Petrosian+ (BAO, 61, 8) showed that satellites of the SBG Mrk 581 are BCD and Irr galaxies. Empirical relations for the determination of the oxygen and nitrogen abundances in HII regions are presented by Petrosian (BAO, 61, 15). Andreasian+ (BAO, 60, 21) obtained the spectra of the Irr galaxy NGC 4753. Sanamian and Oganesian (BAO, 60, 50; 52) discussed the relation between radio properties and Byurakan classes of galaxies. Dokuchaev (LAZ, 15, 387) investigated a problem of of black hole evolution in the nuclei of normal galaxies. Suchkov discussed (AZ, 65, 1) the "hot" model of galaxy formation.

V. Systems of galaxies

Mahtessian gave the new principles for the selection of groups of galaxies (Af, 28, 255). Tischonov has continued the photometrical (Af, 29, 253) and morphological (CAO, 52, 51) investigation of the galaxies in the Nickson compact groups. Sotnikova (Af, 28, 495; 686; AZ, 62, 192) investigated the flows between the components of double galaxies, their axial rotation and morphology. Malumian (Af, 31, 273) found the fact of enhanced radio emission for spiral galaxies in pairs and groups. Amirkanian+ (Af, 29, 395), Amirkanian (BAO, 61, 25) Linde+ (LAZ, 16, 145) calculated M/L ratios and velocity dispersions for the compact Shahbasian galaxies 166, 16, 30, and 4. Artyukh+ (BAO, 60, 24) and Artyukh+ (BAO, 60, 31) carried out radio observations of double galaxies and groups of galaxies at 102 MHz. Amirkanian+ (LAZ, 14, 404) investigated metallicity in the early type members of compact groups. Karachentsev (AZ, 66, 907) discussed the problems of spin orientation of the components of double galaxies. The masses of the elliptical galaxies in double systems are calculated by Demin (AZ, 65, 225). Arkipova+ (AZ, 64, 1161; LAZ, 14, 121) investigated the kinematics of 11 "nests" in VV galaxies. Photometry of VV 242 is carried out by Reshetnikov (Af, 27, 91). Kiseilova+ discussed the numerical method for the identification of triplets of galaxies (LAZ, 14, 970). Mineva (AZ, 64, 1155) calculated the individual masses of the galaxies of triplets. The problem of dark matter in triplets of galaxies was considered by Chernin+ (AC, 1540, 1). Kalloglian+ (Af, 31, 437; 29, 232; 27, 417) made BVR and BV photometry of galaxies in the clusters A 665, A 2256 and A 2634. Statistical analyses of the sample of clusters of bright galaxies were carried out by Iakimov (AZ, 64, 910). Gorbatski (Af, 28, 73) investigated the physical state of intergalactic gas in clusters of galaxies. Berman and Suchkov (LAZ, 13, 843) discussed the problem of hidden mass in systems of galaxies. Zasov (LAZ, 13, 757) examined the relation between gas content, SFR and membership of galaxies in clusters. Shirina (Af, 31, 63) discussed the distribution of dwarf galaxies in Fornax. Ashurov (AC, 1522, 1) examined the unisotropy of the velocities in the Coma cluster. Gubanov (AZ, 65, 1121) presented the results of correlations between structure, population, richness and radio luminosity of clusters of galaxies. Flin and Goblovski (LAZ, 15, 867) examined the distribution of the inclination of galaxies in the Local Supercluster. Lebedev+ (LAZ, 14, 18) calculated the correlation function of superclusters. Fesenko (Af, 30, 71) examined the reality of substructures in clusters of galaxies. Simakov+ (Af, 30, 54) discussed some aspects of evolution of clusters of galaxies. Sokolov (AZ, 65, 236) investigated the distribution of the extragalactic radio sources at 25 MHz. Doroshkevich+ (AZ, 64, 1137) discussed the structure of the universe by means of deep redshift surveys. Fesenko+ (Af, 28, 83) considered angular two-point covariance functions for two samples of galaxies applying quick methods of analysis.

7. Working Group on the Magellanic Clouds
(M.W.Feast)

Magellanic Cloud research continues to be published at the rate of more than 200 papers a year. The topics discussed are relevant to many of the most important areas of astrophysics e.g. the galactic and extragalactic distance scales; stellar evolution, structure and pulsation; the chemical evolution, structure, kinematics and interaction of galaxies. At three year intervals an attempt is made to review the recent work in this very active field. However on this occasion the committee of the Working Group (K.S.de Boer, M.W. Feast (Chairman), N.Suntzeff, N.R.Walborn and P.Wood) decided that a number of other recent reviews were available and that it would be sufficient simply to refer to them.

The main references are:

IAU Symposium 148 (The Magellanic Clouds and their dynamical interaction with Milky Way) (Sydney, Australia, July 1990,

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Kluwer, to be published). The proceedings of this meeting covers most aspects of Magellanic Cloud Research.

Recent Developments of Magellanic Cloud Research, A European Colloquium (Paris, May 1989) (ed. K.S.de Boer, F.Spite and G.Stasinska), Obs.de Paris.

The Magellanic Clouds: their evolution, structure and composition. B.E.Westerlund (Astron.Astrophys.Rev.2, 29, 1990).

In addition there is a section on the Magellanic Clouds in "The World of Galaxies" (ed. H.G.Corwin and L.Bottinelli, Springer-Verlag 1989). This is the de Vaucouleurs festschrift.

A comprehensive review of work on SN 1987A in the LMC was published by W.D.Arnett, J.N.Bahcall, R.P.Kirshner and S.E.Woosley (An.Rev.Astron.Astrophys.27, 629, 1989).

The above conferences and reviews will give an overview of recent developments whilst a comprehensive study of the literature is facilitated by the existence of a special section on the Magellanic Clouds in the volumes of Astronomy and Astrophysics Abstracts.

8. Working Group on Internal Motions in Galaxies
(Charles J.Peterson)

Observational and theoretical study of the internal motions in galaxies continues to be an active endeavor, though the pace of acquisition of kinematic data appears to have slowed somewhat from previous years. The emphasis of published studies in the last three years suggests a trend away from continued accumulation of data on larger samples of objects aimed at better definition of global kinematical properties of individual galaxies as a function of Hubble type or other observational parameters. Rather the research highlighted here is aimed more at answering other types of questions, with motivations for continued observation having shifted toward discernment of evidence for ongoing and past interactions between galaxies, toward attempts to refine the role that dark matter may play in the dynamics of galaxies, and toward seeking evidence for massive black holes in the centers of galaxies.

There is a great interest in observation of galactic systems in obvious interaction, but study of individual galaxies for evidence of past interactions has been reported by a number of observers who have found retrograde gas streaming in the cores of elliptical galaxies, in IC 1459 (Franx + 45.151.220), in NGC 4546 (Galleta 44.157.082), and in NGC 3528, NGC 5898, and A 1029-459 (Bertola + 45.157.248 and 46.157.219). A good discussion of this evidence has been given by Bender (46.157.155). That nuclear gas appears equally likely to be in counterrotation as in corotation with the stars suggests that the gas is the product of acquisition by the galaxies and not the result of internal processes. Counterrotation of nuclear gas has also been observed in the SB0/a system NGC 2217 by Bettoni + (AJ 99, 1789, 1990) and Schweizer + (Ap.J.338, 790, 1989) report counterrotation of both a ring of neutral gas and a central mass of ionized gas in the elliptical IC 2006.

Observation and analysis of rotation curve data, together with analysis of the light distribution within galaxies, continues to be applied toward the study of dark matter distributions. Specific studies include Carignan + (46.157.136) who conclude that dark matter dominates the rotation curve of DDO 154 beyond a radius of 1 kpc, and Jobin + (AJ 100, 661, 1990) who find that NGC 3109 is dominated by dark matter. Persic + (ApJ 355, 44, 1990) have also considered available data. On the other hand, Pryor + (AJ 100, 127, 1990) conclude from modelling of Draco and Ursa Minor that the inability to choose between isotropic and anisotropic models seriously limits an accurate determination of the central dark matter density. Kent (46.157.008) has used both rotation curves and luminosity profiles for 14 Sa galaxies; of these, he finds that half may be modelled with a constant $\mathcal{M}/\mathcal{L}$ and one requires a central dark matter concentration. The remainder suggest a low $\mathcal{M}/\mathcal{L}$ bulge in a high $\mathcal{M}/\mathcal{L}$ disk although the possibility that the rotation curves do not represent the circular velocities cannot be ruled out.

Not unrelated to the dark matter interpretation is the resurgence of interest in the existence of magnetic fields in the disks of galaxies and its influence upon mass motions. It has been argued, for example, by Nelson + (46.151.002) that the kinematic effect of magnetic fields is actually significant and, in fact, may increase apparent circular motions well above the level required for the balance against gravitation; thus, flat rotation curves in the outer parts of galaxies may not require the presence of unseen matter for explanation.

Several investigators have presented evidence for massive objects in the cores of galaxies, either in the form of dense stellar concentrations or massive black holes. These studies include publications on the dwarf elliptical M32 (Tonry 44.157.339), on M31 (Kormendy 45.157.151 and 45.157.228), and discussions of both by Dressler (45.157.087) and Goodman + (ApJ 337, 84, 1989). Gerhard (45.157.162), however, has argued that the kinematic evidence implies a central bar in M31. Independently, Jarvis + (46.157.031) and Kormendy (46.157.371) have concluded that the Sombrero galaxy may contain a $10^9\ \mathcal{M}_0$ black hole in its center. Reviews have been given by Sargent (44.157.126) and by Richstone (45.157.227).

Reviews on other aspects of galaxy internal motions that have appeared in the last three years include Athanassoula + (44.151.047) who summarized an analysis of a large number of rotation curves in *Nearly Normal Galaxies*. Discussions by Kent (44.151.144) on modelling of galaxies, by Kron (44.157.144) on the dynamics of galaxies at large z, and by Fall (44.157.146) on dark matter also appear in this volume. Athanassoula + (46.157.321) and van Albada (46.157.322) have published reviews of the evidence for dark matter in *Large Scale Structure of the Universe, I.A.U. Symposium No.130*. In the same volume Aaronson + (46.157.323) discusses the situation for dark matter within dwarf galaxies. There too has appeared a review on the stellar kinematics of elliptical galaxies by Davies (44.157.151) in *Structure and Dynamics of Elliptical Galaxies, I.A.U. Symposium No.127*.

The following studies on specific types of galaxies should be mentioned. Jarvis + (46.157.047) and Bettoni (AJ 97, 79, 1989) have presented the first results of stellar kinematic observations on SB0 galaxies which hitherto have been relatively neglected. Davies + (46.158.224) have obtained rotational and velocity dispersion data for 14 bright ellipticals with extended radio structures; whereas the rotational axes tend to align with one of the symmetry axes, this is not true for the radio structure. Minor axis rotation data for ellipticals has been analyzed by Jdrzejewski + (AJ 98, 147, 1989) to suggest that ellipticals span the range from oblate to prolate systems. Franx + (ApJ 344, 613, 1989) have also made major and minor axis kinematic observations of elliptical galaxies. A survey of 21 Virgo galaxies in the 21cm line of neutral hydrogen by Guhathakurta + (46.157.029) was designed to study the differences between cluster and field spirals; they find the rotation curves of their sample galaxies are similar to those of more isolated galaxies. Forbes + (ApJ 335, 657, 1989), however, have reanalyzed other rotation curve data for cluster and non-cluster galaxies; contrary to prior results, they find that spiral galaxy mass types are a function of both Hubble type and luminosity. They also find that cluster mass types do differ between cluster and field galaxies.

Detailed studies of a few specific galaxies also may be cited. These include kinematic results on the "grand design" spiral NGC 1566 by Pence + (ApJ 357, 415, 1990) and the work of Edmund + (46.12.651) who have presented TAURUS data on NGC 1365. NGC 1365 has also been studied in the 21cm line of neutral hydrogen by Ondrechen + (ApJ 342, 29, 1989). England has observed (ApJ 337, 191, 1989) and modelled (ApJ 344, 669, 1989) the barred galaxy NGC 1300. Sparke + (45.157.231) have studied the polar ring galaxy NGC 4650A, Held + (AJ 100, 415, 1989) has presented kinematic observations of stellar velocities along the major and minor axes of NGC 205, and Bosma + (45.157.202) have observed the low surface brightness Sc galaxy NGC 5963. Stellar rotational velocities in the Sombrero galaxy NGC 4594 have been obtained by Kormendy + (ApJ 338, 752, 1989; see also Wagner + AA 215, 243, 1989) who show that gas emission line velocities in the central region of the galaxy do not measure the true circular velocity. The rotation curve of the Milky Way Galaxy has been re-evaluated by Fich + (ApJ 342, 272, 1989) out to twice the solar radius.

While our understanding of galaxies is progressing rapidly, a number of problems concerning the internal nature of galaxies still remain to be addressed by detailed kinematical investigation. In particular, the higher resolution of space telescopes such as the Hubble and the introduction at ground-based telescopes of active optics systems to correct for atmospheric blurring will, in the next few years, allow more detailed investigation of stellar and gaseous kinematics to better attack questions about the true nature of central mass distributions. Also more effort may be expected in order to obtain data on stellar absorption line velocities in elliptical systems and in spiral systems. In the latter, stellar data are essential to compare with emission line velocities of the ionized gas to ensure that mass models are securely based upon true measurement of circular velocities.

9. Report to IAU Working Group on Space Schmidt Surveys
(H.C.Arp)

As we all know, NASA long ago commissioned detailed studies on a space Schmidt but never actually initiated construction of the telescope. Later a proposal from astronomers was received by ESA but they also failed to follow up the realization of this modest instrument. The very small cost relative to other space astronomy projects, however, and the fundamental scientific value in broaching the wide field/faint surface brightness frontier makes this project an extremely important one to realize.

At present the most likely source of such observations are from the space Schmidt projected for the Soviet space station "MIR". Design work has been completed on a 1.2 meter, f/3 Schmidt with a field of view of 5° and image size ~ 2 arc sec. The telescope was supposed to have been built in East Germany but I understand it is now uncertain where it will be built. There will also be need for optimal detectors in the 20cm diameter focal plane.

I have been in correspondence with H.M.Tovmassian who is administering ASHOT (Astrophysical Schmidt Orbital Telescope). We feel an ultraviolet image tube such as George Carruthers has constructed and/or high detectivity photographic film such as IIIa with extended spectral and enhanced sensitivity would greatly magnify the performance of this space Schmidt. The problem seems to be how to encourage possibly interested individuals and procure the modest sums of money involved.

NASA is the most obvious source of funding but it would apparently require a formal commitment of observing time from the U.S.S.R. and formal contracts to be signed. Consulting several Russian astronomers has left me with the impression a trip to Moscow would be required to get a time guarantee from ASHOT. Then there is red tape at NASA.

Considering the recent troubles with space astronomy missions I am of the opinion that American astronomers have been too passive with regards to NASA. It seems to me that astronomers should insist on taking responsibility for astronomical instrumentation and observations. Perhaps space Schmidt could represent a modest beginning in this process. It would require some astronomers to propose and the rest to support. Our working group is an obvious source for such initiative.

For the MIR space Schmidt, outside NASA there is the possibility of support from research foundations, observatories or ESA. Again this would be dependant on who might be the principal investigators outside the U.S.S.R. It should be emphasized that as far as the space Schmidt on MIR goes, the telescope will be ostensibly in place in a few years, astronauts (on a schedule of 1-2 months) will be able to change and return to earth surface film cannisters in focal plane cameras and detectors. Of course, some developers of wide field CCD imaging may soon be able to record and telemeter sufficient data back to be superior in information capacity to film and preferable in terms of astronaut servicing. Perhaps we can have a discussion of this at the next working group meeting at the IAU in Buenos Aires in summer 1991.

In a time frame beyond the MIR space Schmidt, the most promising proposal appears to be the tethered space Schmidt concept developed by the Italian group. The tethered Schmidt would be the most practical way to clear the telescope from the contamination of the immediate space platform and at the same time retain the possibility of film retrieval. This would be aimed for the proposed space station "Freedom". Of course, by the time this NASA/International space platform is built, if it is built, telemetered data from a free flying space Schmidt may be less costly in launch and maintenance as well as placeable in a more favorable orbit.

To reiterate, I feel the most pressing concerns for astronomers interested in space Schmidt observations would be to assist with detector instrumentation on the space Schmidt projected for "MIR". On a longer time line NASA and ESA should be pressed to include wide-field, limiting-surface brightness Schmidt telescopes on shuttle flights and space stations. Wide-field electronic detectors should be developed for ultimate survey and faint-surface brightness research.

10. Supernova Working Group
(Virginia Trimble)

The explosion of SN1987A ushered in a brief, golden era, in which the astronomical community was supernova-minded and every event discovered received at least a type spectrogram (many taken by A.V.Filippenko). This era is already over, and some events of the last 9 months have gone untyped. In the triennium, more than half of all published SN papers pertained to 1987A. Other important topics included searches and rates, the mechanism of SN II explosions, the nature of SN I progenitors, new categories SN Ib and Ic, late recoveries of old supernovae, and use of SNe as standard candles for cosmology. Important reviews, conference proceedings, and references include a catalog of events to the end of 1988 (AAp Sup 81, 421); M.Kafatos & A.Michalitsianos, eds, Supernova 1987A in the Large Magellanic Cloud (CUP 1988); T.Piran et al., eds, Supernovae (World Scientific 1990); S.Woosley, ed, Supernovae (Springer-Verlag 1990); A.Petschek, ed, Supernovae (Springer-Verlag 1990); a review of 1987A (Rev.Mod.Phys.60, 859); and one of SN Is by J.C.Wheeler & R.P.Harkness (Rep.Prog.Phys. 1990).

Since the report in IAU Trans.XXA, 300, 1987A has changed a good deal. The expected nuclear γ rays from Co^{56} decay turned on in summer 87 and faded by May 89 (Nature 331, 416; 332, 516; 339, 122; ApJ 334, L81 ff; 357, 638) as did hard X-rays from scattered γs (Nature 330, 227 ff; ApJ 337, L19; A Zh Lett 13, 311; 15, 125). Both appeared earlier than expected, leading to theoretical work on mixing in the ejecta (Nature 330, 233; 333, 534; AAp 197, L7; A Zh Lett 13, 397 & 438; ApJ 327, L5 & 699; 340, 396 & 414; 348, L17). In retrospect it was clear that radiogenic energy had reached the surface by day 20-25, affecting both the light curve and line

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profiles (the Bochum event; AAp 231, 77), probably as a result of a Rayleigh-Taylor instability (ApJ 344, L6). Similar early radiogenic energy may have affected 85L and P.

The presupernova evolution of Sk -69°202 (ApJ 323, L35) and the implications for 87A have been extensively discussed and probably understood (Nature 327, 597; 328, 320; 331, 506; AAp 196, 141; ApJ 319, 664; 319, 136; 324, 466; 331, 377; 341, 867 & 925; 343, 834). The metal abundance of 1/4-1/3 solar (ApJ 330, 28; AAp 182, L31) combined with mass loss, mixing of He into the envelope, and the proper criterion for convective instability probably explains the loop back to a blue supergiant (AAp 224, L7; Proc.Ast.Soc.Aust.7, 75; ApJ 331, 338; 342, 942; 344, 825; 346, 417). Other reasonably well established properties include a main sequence mass near 20 and a core mass near 6 M_o, about half the H envelope lost as a RG wind, production of 0.075 M_o of Ni^{56}, kinetic energy near 10^{51} ergs, and a steep density gradient in the residual He-rich envelope (A Zh Lett 14, 458; 15, 42; MN 238, 15p; 240, 179; Ap J 341, 867; 347, 760). A binary progenitor has also been proposed (AAp 227, L9).

Evidence that Sk -69°202 had previously been a RG includes high N abundance in adjacent blue supergiants (AAp 219, 229), N-rich ejecta detected as sharp IUE lines and probably ionized by shock breakout (Nature 332, 514; ApJ 336, 429; 341, L59) and various interactions between winds and the ISM (AJ 94, 1578; MN 244, 551).

Optical spectra were recorded (Nature 337, 439; AAp 182, L29; 220, 153; AJ 99, 1133) and interpreted (JApA 9, 93; 11, 81; AAp 205, 135) in considerable detail. A tentative s-process excess (ApJ 320, 1117) could have been made in the progenitor (ApJ 331, L15). Infrared spectra provided evidence for early molecule formation (MN 230, 7; Nature 334, 327) with $C^{12}/C^{13} > 10$ and for Co decaying on schedule to Fe (Nature 331, 505; MN 235, 19p; Sci.239, 461; ApJ 347, 1119) in the same amounts as indicated by the γ lines. Dust formation came only after the first year (Nature 337, 533; 340, 697; MN 235, 19p; ApJ 346, L81). Bolometric light curves were reconstructed at SAAO (MN 240, 7p) and CITO (AJ 99, 1146; MN 237, 21p). These have leveled off from Ni^{56} decay curves due to either additional radioactivities or a neutron star.

Complex optical light echos have been seen (Nature 334, 135; AAp 198, L9; MN 243, 555; ApJ 347, L61 & L65) and understood (AAp 229, 427; A Zh 32, 571; ApJ 342, L75). Models for a 0.5 msec pulsar (Nature 338, 234) acquired the status of predictions when an instrumental artifact was diagnosed as the cause.

Finally, the 18, 23, or 28 trapped neutrinos (A Zh Lett 13, 41 & 44) are outnumbered even by sensible papers interpreting them (Nature 327, 682; 329, 689; 330, 609; PASJ 39, 521; PRL 59, 367 & 1865; 60, 33; AN 308, 329; ASS 150, 273; A Zh Lett 15, 338; AAp 180, L20; 186, L11; 189, L10; 201, L44; JETP Lett 46, 373; ApJ 318, L63 & 288; 326, 265; 328, L51, 340 & 426; 329, 326). The consensus is that all is well, 2-6 X 10^{53} ergs (in all species) were emitted at T = 4-6 MeV, cooling in 2-5 s from a neutron star near 1.4 M_o. The neutrino rest mass is less than 16 eV, the magnetic moment less than 10^{-11} μ_B, and the charge also very small (these are perhaps modest improvements over lab limits). Assorted exotic particles are constrained (PRL 60, 1793 & 1797); but MSW can still explain the solar neutrino deficit.

Important issues for SNI's are their use in cosmology and the nature of their progenitors. The majority view is that Ia's do not all have the same light curves or peak brightness (PASP 99, 593; AAp 232, 75; ApJ 330, L113) due partly to differing patterns of Ni^{56} production (ApJ 318, L47), but events in Es are more similar than those in S's 8PASP 101, 588). Typical applications include H = 70±15 from Coma events (ApJ 350, 110) and the ruling out of tired light redshifts from light curves at z = 0.3 (AAp 229, 1).

Evidence has been advanced that SN I's arise from relatively massive stars in S disks (AAp 202, 55) and E/S0 galaxies (ASS 157, 305). Single star progenitors may not grow large enough C0 cores for explosive ignition before winds strip them (A Zh 32, 389). Of the various possible binary models, CVs have trouble retaining the burnt He etc. (ApJ 329, 808; 340, 509; 346, 424), the combination WD + He star may or may not detonate (ApJ 317, 717; ASS 163, 143), WD + RG probably has too much H around though WD + MS is just possible (ApJ 340, 380; 342, L19). This leaves the most popular current model, a merging WD pari (A Zh 30, 598; MN 239, 771; AAp 209, 111; ApJ 324, 355; 342, 986; 348, 647). It is not quite certain that these explode either (Ap J 330, L113; 324, 331; 354, L53). The other major objection to merging WD pairs is a total non-detection of pairs both massive enough and tightly bound enough to merge and explode in a Hubble time (ApJ 322, 315; 333, L87; 345, L91; MN 326, 319).

Detailed nucleosynthesis will differ among the various dense He and Co alternatives (ASS 149, 91; MN 239, 785) and SN Ib's are more likely to have massive progenitors than Ia's (AJ 98, 577; ApJ 343, 323; MN 239, 771). They are clearly He rich, may be about as common as Ia's, and sometimes have a Ni^{56} component (AJ 93, 1372; ApJ 317, 358; 318, L25; 333, 754). The existence of a separable class of oxygen-rich Ic's (including 87M and 88L has been proposed (J.C.Wheeler 1990 preprints).

Type II SNe continue to defy the efforts of theorists to deposit enough energy at the base of their envelopes to make the explosions we see (AN 309, 103; PRL 59, 736; 60, 1999; 63, 716; ASS 143, 15; ApJ 318, L57 & 744; 319, 146; 326, 235; 335, 301; 340, 384 & 955; 353, 597), though a cold, low mass core helps, and 8-10 M_o SNe with core collapse triggered by e capture on Mg, Ne, etc. may be easier to understand (ApJ 318, 307; 334, 090). A high-entropy zone due to pairs and γs from $\nu\nu$ annihilation may provide an adequate piston (Nature 341, 489), though an earlier investigation of the process was not optimistic (ApJ 321, L129). Other SN II items include a 30 M_o lower limit to progenitors in M83 (AAp 192, 57), model atmospheres for Baade Wesselink distances (ApJ 322, 967), and perhaps a new subclass (MN 244, 269).

Thinking about 87A has resulted in the recognition that neutrino-induced nucleosynthesis can be important (Nature 334, 45), that Ni^{56} is likely to affect many light curves (A Zh 30, 670; 31, 629; ASS 146, 375; PASP 102, 299; ApJ 342, L79), and that the numbers of faint SN II's need to be reconsidered. Faint II's tend to occur in faint galaxies (AJ 96, 701), so it is no surprise that they are rare in Shapley-Ames galaxies (ApJ 347, L29), but the median cataloged event has M_B = -16.4 + 5 log h, and the real preponderance of faint SN II's must be even larger (D.L.Miller & D.Branch preprint 1990).

A related issue is that of the total SN rate. Estimates of core collapse rates based on OB stars in molecular clouds and the galactic IMF (ApJ 340, 265; 343, 713) are close enough to the rate extracted from historical SNe (AJ 99, 843) and from extragalactic searches (A Zh 31, 39; AAp 190, 10; ApJ 323, 44) not to leave much leeway for unobservably faint events, though whether we are talking about 1-2 SN II per century in the Milky Way or 3-5 (and a comparable number of SN I's) is still within the dispersion. The SNR birthrate is similarly 2-5/century (PASP 101, 607) and the pulsar birthrate at the low end of that range (ApJ 319, 162). Models of galactic chemical evolution favor higher total rates and ratios of SN II/ SN I averaged over galactic history (ApJ 339, L25). Peripherally relevant data include an upper limit of 1.5/year to neutrino-producing core collapses (PRL 62, 2069) and the general lack of success in searches for young SNRs (MN 244, 12p; AJ 98, 1359 & 1652). Galaxies in which two or more events have been seen in this century may be a distinct population (AAp 206, 219), but nearly all are face-on Sc's, suggesting that observational selection dominates (AAp 231, L27) and that the implied high rate is correct.

The associations among supernovae, remnants, and pulsars remain few and disputed. Tentatively added to the list were 0.039 and 0.267 s pulsars in CTB 80 and W44 (IAUC 4472, 4694), though rejuvenation of old SNRs by invading high velocity pulsars is an alternative (ApJ 346, 860). Psr 1800-21 = G8.7-0.1 may be real (Nature 343, 146), but 1930+22 and G57.3-1.2 are a chance superposition (A Zh Lett 15, 135). Possibly to be subtracted from the list are 3C58 = SN1181 because of the small nebular expansion (ApJ 357, 138) and Vela because the small pulsar proper motion means that it was born far from the nebular center (ApJ 343, L53). And then there is the Fahlman-Gregory object, which may or may not be an X-ray binary NS in a SNR (AAp 195, 114; MN 245, 268).

Not all SNe fit comfortably into the standard classes. 1987B was a spectroscopic II at least 24 h^{-1} kpc from its galactic center (A Zh Lett 15, 129). 1988E initially a Ia, added faint H lines (swept up ISM?) after 300 days (ASS 164, 50); and 1987K, a type II at maximum, was a Ib six months later (AJ 96, 1941).

The very first telescopic SN, 1885A, was finally recovered optically as an FeI absorption line source (ApJ 341, L55), but there is still no radio emission. Other objects followed out to or recovered some years past maximum include 1957B (ESO Mess 56, 36), 1957D, 1961V, 1980K, and 1986J (ApJ 351, 437). SN 1990X had occurred by the end of August, and the year should set a record in number of discoveries. There is more than enough credit to share among Robert Evans, the Berkeley Automated Search, the second Palomar Observatory Sky Survey, Pollas's Schmidt program at Cote d'Azur, and the others who have worked hard to make this so.

11. Galaxy Redshifts

(J.P.Huchra)

Surveys of galaxy and galaxy cluster redshifts continued to be spurred onwards by interest in the large scale structure of the universe. The topology and topography of large scale structures places crucial constraints of theories of galaxy formation, cluster formation and our basic cosmological models. In addition, the last few years have seen significant growth in the industry of measuring relative distances for galaxies to delineate motions (large scale flows) in the universe. Matching such motions with the density field determined from uniform, whole-sky galaxy redshift surveys offers perhaps the best hope of determining the local mass density of the universe.

Since this reporter's last report three years ago, the number of galaxies with measured redshifts has gone from nearly 25 000 to nearly 40 000. The majority of these can be found in either of two large compilations; one maintained at the Center for Astrophysics by J.Huchra and collaborators and one maintained at Bologna by G.Palumbo and G.Vettolani. Versions of these are obtainable from the National Space Science Data Center (NSSDC) in the U.S. or the Strasbourg Astronomical Data Center (CDS) in Europe. A somewhat more detailed catalog of galaxy properties, *The Third Reference Catalogue*, is nearing completion by de Vaucouleurs, Corwin and Buta. These catalogs contain several "complete" sub-catalogs, including the Revised

Shapley-Ames catalog (RSA), the first CfA Survey (CfA1), the Southern Sky Redshift Survey (SSRS), the Nearby Galaxies Catalog, and the first CfA Slice (CfA2).

Similarly, the number of galaxy clusters from the lists of Abell, Zwicky, Corwin and Olowin and deeper surveys (e.g. Gunn and Oke, and Sandage et al.) with measured redshifts is over 1000. Catalogs of cluster redshifts are maintained by H.Rood and M.Struble, and by J.Huchra in the U.S., and by M.Kalinkov and I.Kuneva in Bulgaria, T.Fetisova in the U.SD.S.R. and H.Andernach in Brazil. Two new and major complete samples of cluster redshifts have been completed by Huchra, Henry, Postman and Geller: a deep sample of 145 Abell clusters near the north ecliptic pole and a large area survey of 350 Abell clusters with $m_{10} \leq 16.5$. These surveys confirm the large amplitude of the cluster-cluster correlation function originally found by Bahcall and Soniera.

Major large area surveys of optically selected galaxies (from the catalogs of Zwicky et al., Vorontsov-Velyaminov, Nilson, and Lauberts et al.) continued to be carried out by Giovanelli and Haynes at Arecibo, by Huchra and Geller at Mt.Hopkins, by da Costa et al. in Brazil, and by Fairall in South Africa. Deeper redshift surveys, usually over smaller areas where galaxies are selected either by scanning photographic plates or by digital surveys, are being done by Kirshner, Oemler, Schechter and Shectman at Las Campanas and McGraw Hill, by Dressler and Faber at Las Campanas, by Koo, Kron and Szalay at Kitt Peak, by Ellis, Shanks and Broadhurst at the AAT, by Geller et al. at the MMT and McGraw Hill. Three major results have been produced by these surveys: the discovery of the "Great Wall" by Geller and Huchra (*Science* 1989), the possible discovery of periodic structure in the redshift distribution by Broadhurst et al. (*Nature* 1990), and the mapping of the backside of the "Great Attractor" by Dressler and Faber (*Ap.J.* 1990).

Successes have now been obtained with a multiple object fiber-coupled spectrograph at several telescopes: AUTOFIB and FOCAP at the AAT, NESSIE at KPNO, OPTOPUS at ESO, MX at Steward, DECASPEC at McGraw Hill, and FLAIR at the 1.2m U.K.Schmidt. These systems, when fully operational, are capable of increasing the annual production of redshifts from a few thousand to over 10 000.

Samples of objects selected from the IRAS scans have been used to provide whole sky, complete samples of for the study of the nearby potential field. A large survey of all 2600 objects brighter than 1.936 Jy at 60 μ and further than 10° from the galactic plane has been completed by Strauss, Davis, Huchra, Tonry and Yahil. A sparse sample (1 in 6) to a much fainter limit (0.6 Jy) has been completed by Rowan-Robinson, Lawrence and Sanders. These samples show remarkable overall agreement between the potential field, measured from the galaxy distribution, and the velocity (flow) field measured by Lynden-Bell et al. (the Seven Samurai), but many details remain in conflict, particularly the match in the Perseus-Pisces region.

Lastly, in addition to the large number of moderately high quality velocities that have been published in the preceding three years, a significant effort has been made by Tifft and Cocke (e.g. *Ap.J.Supp.***67**, 1) to improve the number of "standard" or calibrating galaxies for radial velocity work. Similar efforts are underway to provide good templates for absorption line velocities and velocity dispersions.

In closing, I would like to once again stress to all astronomers the need to publish heliocentric velocities (cz) or redshifts (as $z = \Delta\lambda/\lambda$ in the optical convention), and also to publish accurate positions for the galaxies they observe. This policy was adopted by the members of the Working Group on Galaxy Radial Velocities present at our meeting during the 1988 IAU General Assembly.

12. Working Group on Nomenclature
(K.S.de Boer)

The WG on Nomenclature was restructured but at the moment of writing no activities can be reported.

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