COMMISSION 28: GALAXIES

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This report covers the period 1 July 1984 to 30 June 1987 and - as usual - has been prepared by the President, Vice-President, members of the Organizing Committee and the chairpersons of the Working Groups. There has been emphasis on highlights rather than on completeness of references. In comparison with earlier reports one section (Galactic Dynamics) has been added, but otherwise the same line of reporting has been used. For readability and quick reference, in general abbreviated notation for literature references to major journals have been used; more complicated ones usually follow the code of Astronomy and Astrophysics Abstracts. The abbreviation et al. has been replaced by the symbol +.

1. Highlights since Delhi
(V.C. Rubin)

The arrival of optical photons and neutrinos from a supernova in the LMC has surely made the present time one of the most exciting period for extragalactic astronomers. Moreover, other galaxy studies during the last 3 years have led to many significant advances;some are of such fundamental importance that they will will alter the way in which we look at the universe. While my predecessors have used this space to detail survey work, catalogues, and observations in various spectral ranges, I will use this opportunity to make some general comments on three exciting topics which I view as the highlights during the past few years.In successive years, such reports could constitute an interesting historical document of which accomplishments we viewed as most important.

I. SN 1987a

On february 23, 1987, the 15-29 solar mass star SK-69.202 "went supernova"; in less than a few seconds most of the released gravitational energy ($\sim 10^{53}$ ergs) was emitted as neutrinos, of which one in 10^{47} traveled through the earth. Of those wich interacted with matter, 19 were detected by sensitive detectors at Kamioka, Japan and outside of Cleveland, Ohio, USA. Within these few seconds, the sience of observing neutrinos from supernovae was born. Surely these seconds rank among the most important in the history of astronomy. Present analysis of the observations sets a likely upper limit to the neutrino mass at about <25 eV.

At the time of this writing, June 1987, SN 1987a has peaked at all observed wavelenghts, and its luminosity is slowly decreasing. While it seems likely that its luminosity in the X-ray, the γ-ray, and the UV spectral regions will increase in the coming months or years, a significant dust component may blot out our optical view. Still to be explained is the speckle observation of a bright companion (now the second brightest object in the LMC) only 0.06 arcsec away from the SN. Reflection? Object? Its properties are presently unknown.

While the theorists rejoice with the observational confirmation of theories of core collapse and SN production, observers question why the SN is less bright than expected, and the role of the companion object. We can anticipate an enormous

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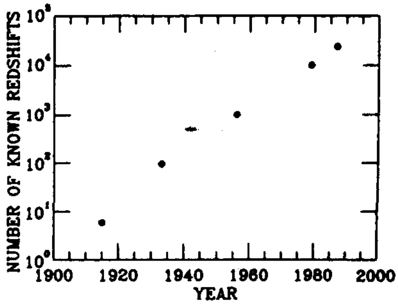
increase in our knowledge of SN within the next decade, due to our very great fortune in having appropriate detectors available when the event occured. We can hope for a second naked-eye SN before 2019, thus to better the Brahe/Kepler record of SN 1572a and 1604a.

II. REDSHIFT SURVEYS, LARGE-SCALE STRUCTURE, AND LARGE-SCALE MOTIONS

Conclusions from studies of the large-scale structure and of large-scale motions within hundreds of megaparsecs have produced intreging results; this is probably the most exciting time to be studying the large-scale universe since Zwicky and Smith noted the high velocity dispersion of galaxies in the Coma and the Virgo clusters. The distribution of galaxies in the universe remains clumpy on scales extending to the distances of the deepest surveys. This result in each of the many redshift surveys.

The total number of redshifts is now about 24,000; up from 10,000 in 1979 (Fig. 1), and it is increasing at a rate of several thousand velocities per year. We should easily have 100,000 by the year 2000; it is difficult to guess if will have observed 1,000,000 by the year 2010. But we are well on the way to the 10^6 redshifts that Ambartsumian said we will require in order to understand the universe.



Large area surveys have determined velócities of all IRAS galaxies with intensities greater then 2 Jy (Davis, Huchra, Tonry, Yahill, and others); velocities of 2000 optically selected ESO galaxies (Da Costa, Davis, Fairal, Sargent and others); and velocities of 4000 galaxies complete to m=15•5 contained in four slices (Geller and Huchra). Velocity surveys in clusters of galaxies, independently made in the USSR (Koplov, Karachentsev, and Klypin) and in the US (Postman, Huchra, and Henry; Gionavelli and Haynes) have added thousand of more radial velocities. And pencil-beam surveys (Ellis, Efstathiou, and Peterson), those narrow regions extending as far as m=22 (Koo, Kron, and Szalay), have confirmed that even at these large distances, the distribution of galaxies in redshift space is not smooth. Where is the smooth, isotropic universe we were all taught to expect?

In a universe in wich the random motions of galaxies are small, three-dimensional plots of redshifts and positions will map the distribution of galaxies. But if random motions are not small, or if systematic streaming motions exist on scales wich are large then the transformation from position-redshift to position-distance is non-trivial.

Major observational programs to map large scale bulk motions on scales of 100's of Mpc have produced equally surprising results. Distances to galaxies, independent of their observed velocities, are required. The set of residual velocities from a smooth Hubble flow are then analysed for systematic patterns, with the cosmic microwave background defining the rest-frame.

Almost without exception, analyses for a bulk motion all imply a motion of the nearby galaxies with a velocity in the 500-700 km/sec range, in a direction not far from the apex of the microwave dipole. Aaronson and colleagues, who have studied galaxies in clusters, and de Vaucouleurs and Peters have used the Tully-Fisher relation to obtain absolute magnitudes, and hence distances; Faber and her six colleages have used the Faber-Jackson relation with a modified magnitude criterion. Even the 1976 Rubin-Ford ScI galaxies, as well as a new sample of rotation curve spirals, determine a motion whose apex is within 20° of the MWB apex. In regions

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where the various studies overlap, there is a good agreement among the residual velocities. Many questions still remain. Is a model based on the attraction of a single dominant mass a better fit to the observations than a model based on a bulk flow? How significant are the differences between the solutions; are they merely all optical approximations to the microwave dipole?

Motions this large put serious constraints on the properties of the early universe. We have much to learn concerning the large-scale distribution of matter of motions, but progress has been rapid in the last few years; we can anticipate exciting new discoveries in the next three years.

III. GALAXIES IN THE INFRARED

From January until November, 1983, the Infrared Astronomical Satellite (IRAS) scanned the sky at wavelengths of 12, 25, 60, and 100 μm, ultimately viewing 98% of the sky at wavelengths inaccesible from the ground. Over 20,000 galaxies were detected, primarily at 60 and 100 μm, and revealed a view of the extragalactic universe only dimly perceived previously. New insights into galaxy evolution, active galactic nuclei, and QSOs have been obtained, and still offer much to be learned. Advances in our knowledge of external galaxies, surely as great as those which came from the initial 21-cm observations, have once again come from opening up a new spectral band.

"An exciting and surprising revelation". That is what G. Neugebauer has called the observation that some galaxies emit more than 50% in the infrared and as much as 30^0 to 300^0 K is sampled; in galaxies this radiation corresponds to emission from large dust comlexes which have been heated by starlight. The surprise that came with this discovery that many peculiar, disturbed, or tidally interacting galaxies emit 98% of their energy in the IR compared with galaxies of undisturbed morphology, where the fraction emitted in the IR is less than half.

Follow-up ground based studies of IRAS galaxies indicate short phases of active massive star formation, probably induced by the supersonic collision of gas clouds in gravitational interacting galaxies. Star formation rates ten times normal are experienced over relatively short time scales, generally within a few kilopasecs of the nucleus. Heavy-element enrichment at small radii is thus a natural consequence of such models. Extension of these ideas to even larger scales may account for QSO activity. Overall, IRAS observations have offered a new approach to the study of galaxy evolution, and have taught us how important is the role of gas in the evolution of galaxies.

IV. IMPORTANT CATALOGUES AND ATLASES
(prepared by J. Lequeux)

1984 - Rosa +	IUE UV spectra of extragalactic HII regions I the catalogue and the atlas, AA Suppl. 57, 361
Sandage +	(Atlas of dwarf galaxies in the Virgo Cluster) AJ 89, 919
Helou +	(HI observations of magnitude-limited sample of Virgo spiral galaxies) ApJ Suppl. 55, 43
1985 - Verter +	Catalog of CO observations in galaxies ApJ Suppl. 57, 261
Takase +	An atlas of selected galaxies with illustrations of photometric analyses U. Tokyo press
Karachentseva +	Atlas of dwarf galaxies in the region of the M81 group AA Suppl. 60, 213

	Grosbol +	(Catalogue of disk parameters for 605 galaxies) AA Suppl. 60, 261
	Lonsdale +	Catalogued galaxies and quasars observed in the IRAS survey, JPL
	Ballick +	Catalogue of dusty elliptical galaxies A.J. 90, 183
	Sandage +	(Atlas of Virgo Cluster spiral galaxies) AJ 90, 395
	Binggeli +	A catalog of 2096 galaxies in the Vigo cluster area AJ 90, 1681
	Bothun +	A catalog of radio, optical and infrared observations of spiral galaxies in clusters ApJ Suppl. 57, 423
1986 -	Gallagher +	UBV colors of Virgo cluster irregular galaxies AJ 92, 557
	Mazzarella +	A catalog of Markarian galaxies ApJ Suppl. 62,
	Huchtmeier +	HI observations of galaxies in the Kraan Korteweg-Tammann Catalogue AA Suppl. 63, 323
	Wevers +	The palomar-Westerbork survey of northern spiral galaxies AA Suppl. 6, 505
1987 -	Hoffman +	(HI survey of dwarf irregular galaxies in Virgo) ApJ Suppl. 63, 2476
	Bettoni +	A catalogue of early type galaxies with emission lines AA Suppl. 67, 341
	Gioia +	Radio continuum observations of early and late-type spiral galaxies ApJ Suppl. 63, 4
	Deutsch +	Far-IR luminosities of Markarian starburst galaxies ApJ Suppl. 63, 803
	Lewis +	HI survey of face-on galaxies: the frequency of distortions in HI disks ApJ Suppl. 63, 515

2. Structure and Evolution of Galaxies
(J. Lequeux)

Many recent meetings have been devoted totally or partly to this field: 1984: "Spectal evolution of galaxies", ed. Gonghalekar, RAL report 84-008; 1985: "Theoretical aspects on structure, activity and evolution of galaxies", ed. Aoki +, Tokyo Astr.; "New aspects of galaxy photometry", ed. Nieto, Springer, Verlag; "The Virgo cluster of galaxies", ed. Richter, ESO; "Extragalactic infrared astronomy", ed. Gondhalekar, RAL report 85-086; "Production and distribution of CNO elements", ed. Danzinger +, ESO; "Birth and evolution of massive stars and stellar groups", ed. Boland +, Reidel; "Spectral evolution of galaxies", ed. Chiosi +, Reidel; "Star forming dwarf galaxies", ed. Kunth +, Editions frontières; "Luminous stars and associations in galaxies", ed. de Loore + (IAU Symp. 116), Reidel; "Light on dark matter", ed. Israel (first IRAS conf.), Reidel; "Stellar populations", ed. Norman +, Cambridge U. Press; "Gaseous halos of galaxies" ed. Bregman +, NRAO. To be published: "Nearly normal galaxies", ed. Faber (Santa Cruz), Springer Verslag; "Starbursts and galaxy evolution", ed. Montmerle + (moriond), editions frontières; "Stellar evolution and dynamics in the outer halo of the galaxy", ed. Azzopardi +, ESO; etc. One should mention the book by Hodge "Galaxies" Haward U. Press.

I. ELLIPTICAL AND LENTICULAR GALAXIES

1. Structure and Evolution

Kormendy (ApJ 292, L9; 295, 73) shows that the cores of ellipticals (and bulges) are generally not isothermal, and that dwarf E and SO galaxies are not connected genetically to giant E, a conclusion confirmed by van den Berg (ApJ 91,

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271) and Ichikawa (ApJ Suppl 60, 475) although Wirth + (ApJ 282, 85) do not agree. The presence of disks in ellipticals is indicated by Kodaira + (ApJ Suppl 62, 703), Carter (ApJ 312, 514) and Bender + (AA 177, 71) while Michard (AA 140, L39) also finds similarities between flattened E and S0. Color and metallicity gradients in E have been found by Estathiou + (MN 215, 37P), Baum + (ApJ 309, 572), Carter + (ApJ 315, 451) while Glass (MN 211, 461) finds no IR color gradients and Boroson + (AJ 92, 33) find color gradients only in the most lumious E Shells have now been discovered around many (Fort + ApJ 306, 110; hence ApJ 310, 597) and are usualy considered as resulting from merging (Dupraz + AA 166, 53; Huang + AA 174, 13). On the other hand, the galaxy NGC 6166 is no longer considered as cannibalizing smaller galaxies (Lachieze-Rey + AA 150, 62; Lauwer ApJ 311, 34). Globular clusters have been found and studied in a large sample of E up to the Coma Cluster (Haris + ApJ 287, 175 and 185; 291, 147; 315, L29; AJ 91, 822; Prichett + AJ 90, 2027; Hanes + ApJ 300, 279; 304, 599; 309, 564; Grilmair + ApJ 91, 1328, Thomson + ApJ 315, L35); although they differ from those in spirals (van den Berg + AJ 90, 535; Mould + AJ 92, 53) they might be usefull as standard candles. Variations of parameters with luminosity amongst E have been studied by Mould (PASP 96, 273), Pickles (ApJ 294, 134; 296, 340), Rose (AJ 90, 1927), Vader (ApJ 306, 390) and others, with the main result that metallicity is correlated with luminosity. Djorgovski + (ApJ 313, 59) finds that E form a 2-parameter family (surface brightness and velocity dispersion). Several authors have tried to explain these statistical results in terms of formation and evolution. Weeraghavan + (ApJ 296, 336) find no objection for E resulting from merged S, but this possibility is dismised by Kent (ApJ Suppl 59, 115) and Lake + (ApJ 310, 605). Vader (ApJ 306, 390) finds little difference between cluster and field E while Bica + (preprint) claim that field giant E and S0 have fainter metallic lines. Dwarf E have been suggested to be stripped dwarf irregulars, but the studies of Bothun + (AJ 92, 1007), Thuan (ApJ 299, 881) and Binggeli (in Star-Forming Dwarf Gal. 53) show that this is unlikely in the Virgo Cluster. Alternative models for the formation of E invoke galactic winds at early stages (Vader ApJ 305, 669; Arimoto + AA 133, 23; Yoshii + AA, in press).

The problem of whether E have an intermediate-age population is still controversial. While spectral synthesis or colors suggest to Burnstein + (ApJ 287, 586), Rose (AJ 90, 1927), O'Connell (in Stellar Populations, 167), Thuan (ApJ 299, 881) and Rocca-Volmerage + (AA 175, 15), the presence of a large amount of stars 5-10 Gyr old, this conclusion is disputed by Renzini (in Stellar Populations, 213). Hamilton (ApJ 297, 371) finds all E up to z=0.8 to be much more than 8 Gyr old. The nature of the UV excess might well be due to old evolved objects (Nesci + AA 145, 296; Mochkovitch AA 157, 311; O'Connell + ApJ 303, L37). However some authors favor a young population (Kjaergaard AA 176, 210; Bertola + ApJ 303, 624) in some giant E.

2. Gas and Young Stars

It is now clear that many E and S0 galaxies contain gas and dust and presently form stars, although massive stars only in small quantities. Neutral hydrogen has been detected in many (and even CO in NGC 185: Wiklind + AA 164, L22). In E its morphology and other properties suggest that it has been accreted (Knapp + AJ 90, 454) and it is often very extended (Wilkinson MN 217, 779; van Gorkom + AJ 91, 791; Lake + ApJ 314, 57). An HI bridge has been found between a dwarf galaxy and the giant E NGC 4472 (Sancisi + ApJ 315, L39). The situation for S0 seems more complex. Many have inclined HI disks (e.g. Sancisi + MN 210, 497; Krumm + AA 144, 202; Knapp + AA 142, 1; van Gorkom + ApJ 314, 457) and the gas is very extended (Chamareaux + AA Suppl 69, 263; Shostak AA 175, 4), suggesting accretion; the culprit may have been found for NGC 1023 (Cappaccioli + AA 169, 54). NGC 5084 may be a counter-example to accretion (Gottesman + MN 219, 759). Dust is present in 25 (Lauer MN 126, 429) to 40 per cent (Sadler + MN 214, 177) of E. NGC 5266 is an E where coinciding dust and HI rings have been seen (Varnas + ApJ 313, 69). More than 50 percent of E show far-IR-emission (Jura + ApJ 312, L11) from dust heated by the

50 per cent of E show far-IR-emission (Jura + ApJ 312, L11) from dust heated by the general radiation field (Jura ApJ 306, 483; Wrobel + ApJ 311, L11) although star formation may contribute (Brosch MN 225, 257). More than half of the E and S0 also contain ionized gas (Demoulin-Ulrich + ApJ 285, 527; Phillips + AJ 91, 1062; Wodge + AJ 92, 291) which may or may not coincide with HI dust (e.g. Phillips + Nature 310, 733; Davies + ApJ 302, 234). The ionization may be through non-thermal UV radiation (Rose + ApJ 285, 55; Wilson + ApJ 291, 627; Tadhunter + Nature 325, 504; Robinson + MN in press) but there are counter-opinions (Diaz + MN 214, 41P). Hot gas giving X-ray emission is common place around giant E in clusters (Fabian + Nature 310, 733; Steward + ApJ 285, 1; Forman + ApJ 293, 102; Stanger + MN 229, 363; Trinchieri + ApJ 310, 637; Canizares + ApJ 312, 503; Maccagni + ApJ 316, 132); note that old low-mass stars contribute to the X-ray emission (Trinchieri + ApJ 296, 447). This gas cools and settles in the central region and star formation is expected, as well as from the cold gas. Indeed recent star-formation is seen either as blue nuclei (Vigroux + AA 139, L9) or spectral features (Véron + AA 145, 433; Johnstone + MN 224, 71) or perhaps distortions in the optical appearance (Nulsen MN 225, 939). Star formation is not very active and, in the case of S0, not correlated with the amount of gas (Balkowski + AA 167, 223). Where has the cooled gas gone? Perhaps it forms only low-mass stars (Romanishin ApJ 301, 675; Fabian + ApJ 305, 9; Silk + ApJ 307, 415; Nulsen MN 221, 377).

3. Dwarf Spheroidal Galaxies

Intensive activity has been deployed on the "seven dwarfs" around our Galaxy: L-M diagrams (da Costa ApJ 285, 483; Olszewski + AJ 90, 2221; Buonnano + AA 152, 65; Stetson + PASP 97, 908; Carney + AJ 9, 23; Cudworth + AJ 92, 766), surveys of carbon stars (Azzopardi + AA 144, 38; 161? 232 and in prep.; Westerlund + AA 178, 41; Demers + in prep.; Aaronson + ApJ. 296, L7), infrared stellar photometry (Aaronson + ApJ 290, 191), abundance determinations (Bell PASP 97, 219; Suntzeff + AJ 91, 1091). The presence of carbon stars, the diagrams and the spread in metallicities indicate star formation over a long period, with the last episode a few billion years ago. M81B might be a dwarf spheroidal with present star formation (Schmidt + ANachr 306, 257). Morphologically the dwarf spheriodicals are more related to the dwarf E (Kormendy ApJ 295, 73) but the existence of a generic relationship is not established.

II. SPIRAL AND IRREGULAR GALAXIES

1. Structure of Normal Galaxies

Separation and statistical properties of bulges and disks have been discussed by Kent (ApJ Suppl 59, 115), Simien + (ApJ 302, 564) and Kodaira + (ApJ Suppl 62, 703) (see also Schombert + AJ 91, 60): only the bulge/disk ratio is well correlated with the Hubble type and there seems to be a discontinuity between E, S0 and S, dismissing the possibility of type-to-type evolution.

Population syntheses in nuclei indicates a composite population (Frogel ApJ 298, 528; Ciani + AA 137, 223), a possible metallicity gradient in M31 (Martinez-Roger + AA 161, 237) and variations in metallicity and fraction of young stars from nucleus to nucleus (Bica + AA in press). The properties of X-ray emission indicate a population of low-mass binaries in the M31 bulge (Fabbiano + ApJ 316, 127). Many bulges contain gas (Mathews + ApJ 312, 66) often ionized; contamination by stellar lines complicates its study (Rubin + ApJ 305, L35). The bulge of M31 contains dust (it is a strong far-IR source: Soifer + ApJ 304, 651) and ionized gas with a complex distribution (Jacoby + ApJ 290, 136) and kinematics (Boulesteix + AA 178, 97), wich appears connected with a strange radio-continuum structure (Walterbos + AA 150, L1). However there are no massive stars in this region, and the UV excess is due to evolved stars (Bohlin + ApJ 298, L37).

Surface photometry of disks confirms the absence of color gradients (Carignan ApJ Suppl 58, 107) including in the IR (Glass MN 211, 461; Beckman + AA 161, 70; Walterbos + AA Suppl 69, 311); local regions of star formation are somewhat bluer. Old-star spiral arms can be seen in some galaxies (Kennicut + ApJ 300, 132; Adamson + MN 224, 367). The constancy of the general brightness, expotential decrease and cut offs at about 4.5 scalelengths are confirmed in an unbiased sample of isolated galaxies by van der Kruit (AA 173, 59) who suggests that this is naturally explained by the momentum-conserving collapse of uniform rotating spheres. Grand design S are somewhat larger than the flocculent ones (Elmegreen + ApJ 314, 3) but their differences in color are marginal (Romanishin). Irregular galaxies, dwarf I and some blue compact galaxies have normal disks (Schild Aplett 24, 85; Carigan ApJ 299, 59; Loose + in Star Form. in Dwarf Gal. p 73; Comte +, in prep.) although weaker (Manousoyannaki + AA 160, 331) and their JHK colors are rather uniform except in extreme cases (Hunter + AJ 90, 1457). Loose + ApJ 309, 59 claim that the blue compact Ho2 has an underlying E. The apparent flattening distribution of the I is simular to that of the spirals, but the dwarf I might be triaxial (Feitzinger + AA 167, 215). HI has been mapped in many S galaxies in particular M31 (Brinks AA 141, 195; 169, 14) M33 (Deul + AA Suppl 67, 509) and NGC 6946 (Tacconi + ApJ 308, 600); one of the most interesting features is the presente of holes probably dug by stellar winds and supernova explosions. Strong warps are frequent (e.g. Appleton + MN 212, 393). A statistical study shows that HI disks as extended as the optical disks can produce the observed CaII absorption in extragalactic sources (Morton + ApJ 302, 272). Dwarf I and blue compact galaxies often have a relatively large HI extent (Krumm + AJ 89, 1319; Huchtmeier + AA 143, 216; Hunter + AJ 90, 1464) but their morphology varies from a regular disk to a clumpy irregular gas distribution (Sargent +, Skilman +, Comte +, Brinks +, in Star Form. in Dwarf Gal., resp. pp 253, 263, 273, 281; Briggs ApJ 300, 613). Bothun + (AJ 90, 697) show that dwarf E in the Virgo Cluster have no HI, and cannot be quiescent dwarf I.

CO has been detected in many galaxies (Verter ApJ Suppl 57, 261; Young + ApJ 288, 487; Odenwald ApJ 310, 86, etc.) and even ^{13}CO (Rickard + ApJ 292, L57; Young + ApJ 302, 680). Dickman + (ApJ 309, 326) state that the amount of H_2 can be derived from the line intensity. The latter is proportional to the blue Luminosity both in Virgo Cluster and field galaxies (Young + ApJ 288, 487). The distribution of CO differs from that of HI; this is probably related to the formation/disruption of molecular clouds (Allen + Nature 319, 296; Wyse ApJ 311, L41). Detailed CO maps of portions of M31 have been made, showing individual giant molecular clouds (Boulanger + AA 140, L5; Ryden + ApJ 305, 823; Casoli + AA 173, 43; Ichikawa + PASJ 37, 439). M33 is more difficult (Blitz ApJ 296, 481) but Viallefond + (in prep.) have detected and mapped CO in many places. The Caltech interferometer is producing detailed CO maps (IC 342: Lo + ApJ 282, L59; NGC 6946: Ball + ApJ 298, L21, ect): these observations and others show that CO is an excellent tracer of bars (Ohta + PASJ 38, 677) and rings (Garman + AA 154, 8). No CO has been found in two clumpy I galaxies (Sofue + PASJ 38, 161), only weak emission in several I (Tacconi + ApJ 290, 602) and none in dwarf I and blue compacts (Israel + AA 168, 369; Combes + in prep.). This is not too surpising given the low metallicity (also explaining their low far-IR flux: Gondhalekhar + MN 219, 505). Crawford + (ApJ 91, 755) have detected using the Kuiper Airborne Observatory the C^+ 158 μm line in 6 galaxies. Its intensity is proportional to that of CO and its space distribution is very similar, while in relation with HI. A large amount of data on dust is coming from IRAS observations (Becklin in light on Dark Matter p. 415). Studies in our galaxy (Boulanger + ApJ in press; Pérault + in prep.), in M31 (Walterbos, thesis) and in other galaxies (Lonsdale-Persson + ApJ 314, 513) show that in normal galaxies the larger fraction of the dust is heated only by the general radiation field (the "cirrus" component) and thus that the far-IR emission is not a good indicator of star formation. A variable construction of star-forming regions explains the observed anticorrelation between the 12/24 μm and the 60/100 μm flux ratio (Helou ApJ 311, L33). The effect of optical thickness may not be negligible even at 100 μm since face-on galaxies are statistically stronger 100 μm emitters than the edge-on ones (Burstein + ApJ 301, 693).

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radio-continuum studies have confirmed that the non-thermal radiation of S has an exponential distribution similar to the blue light (Harnett MN 210, 13, etc.). However M81 has a ring structure (Beck AA 152, 237). The radio brightness is correlated with the B-H color, an indicator of recent star formation (Burnstein + ApJ 315, L99). Higher-resolution observations show a bar and arms in M83 (Ondrechen AJ 90, 1474) and arms in M81 (Bash + ApJ 310, 621). Walterbos + (AA Suppl 61, 451) and Viallefond + (AA Suppl 64, 237) find terminal sources in M31 sometimes coinciding with optical HII regions and nonthermal sources. Dwarf I and blue compact galaxies are weak radio emitters as expected (Altschuler + AA 177, 22) with a flatter spectrum than S (Klein AA 141, 241; 161, 155; 168, 65; Sramek + ApJ 302, 640). The structure of the magnetic field has been studied in several S through radio polarization (Sofue + AA 144, 257; Ap. Sp. Sci. 19, 191; Scarrott + MN 224, 299; Beck + AA 152, 237; Vallée AJ 91, 541) or optical polarization (King MN 220, 485); it generally follows the arms. Baryshnikova + (AA 177, 22) make dynamo models to explain this. Hummel (AA 160, L4) finds that deviations from the radio continuum/ 100 µm mean relation (de Jong + AA 147, L6) have the same distribution as $B^{1.9}$ if B is the equipartition magnetic field, a strong argument in favor of equipartition.

Further studies have been made of the z-distribution of radio radiation in edge-on galaxies (Schlickheiser + AA 140, 277; Sukumar + MN 212, 367; Werner AA 144, 502; Harnett + MN 215, 247; Broeils + AA 153, 281). Extended radio emission is always present, with often a steepening of the spectral slope; several authors find agreement with the dynamic halo model. Attempts to find hot-gas emission in the halo of NGC 4244 have given marginal results (Deharveng + AA 154, 119). Bothun (AJ 90, 1982) has discussed the constaints on HI in halos. New surveys of globular clusters in M31 have been performed by Crampton + (ApJ 288, 494), Battistini +(AA Suppl 67, 447) and Wirth + (ApJ 290, 140), the latter concentrating on the difficult central regions. Globular clusters have also been found around NGC 2683 (Harris + AJ 90, 2495) and NGC 253 (Blecha 154, 321). IR photometry has been performed by Sitko + (ApJ 286, 209) for globular clusters in M31 and Andromeda dwarf E: a M_k, J-K relation offers hopes for using globular clusters as distance indicators. Comparisons of globular clusters in different galaxies have been made by Burnstein + (ApJ 287, 586) and Zinn (in Stellar Populations p. 73).

2. Individual Stars, Color Magnitude Diagrams

Local-group galaxies are sufficiently nearby for CM diagrams to be built and even spectra to be taken of individual stars. CM diagrams in outer parts of M31 have been obtained by Crotts (AJ 92, 292): the disk shows a mixture of ages and populations, the outer bulge (or halo) has a large spread in metallicities but the authors seem to disagree as to the mean of metallicity. The halo of M33 is of lower metallicity (Mould + ibid.). Massey + (AJ 92, 1303) and Odewahn (AJ 92, 310) have obtained CM diagrams in star-forming regions of M31 and the former made detailed studies of the stellar population. Upper CM diagrams have been obtained for many local-group irregulars (Hoessel + ApJ 286, 159; ApJ 286, 159; ApJ Suppl 60, 507; Demers + ApJ 89, 1160; 90, 1967; Sandage + ApJ 90, 1019 and 1964; 91, 496; Walker MN 224, 935) and more distant galaxies (Freedman ApJ 299, 74; Pierre + AA, in press). The upper luminosity function (OB stars) is simular in all the galaxies exept perhaps M81 and indicate similar initial mass functions (Hoessel IAU Symp 116, p 439; Scalo, Fund. Cosm. Phys. 11, 1). Surveys have been performed in several S and I: variables (e.g. Kinman + AJ 93, 833); carbon stars and M giants (Richer + ApJ 298, 240; 298, L31; Cook + ApJ 305, 634; Aaronson, in Stellar Populations p. 45) (their ratio depend on metallicity); S stars (Aaronson + ApJ 291, L41). Planetary nebulae (Nolthenius + ApJ, preprint; Lequeux + AA Suppl 67, 1); Wolf-Rayet stars (Bohannan + AJ 90, 600; Armanhof + ApJ 291, 685; Lequeux +, ibid.; Azzopardi + AA, in press.): according to the latter authors, the relative abundance of Wolf-Rayet stars depends critically on the galaxy metallicity. Wolf-Rayet features are commonly seen in the spectra of extragalactic HII regions (Kunth + AA 142, 411;

169, 71; Keel AA 172, 43; Campbell + and Rosa IAU Symp 116). Photometry and spectroscopy of individual stars have been made for many candidates in the surveys above and for supergiants (Humphreys + AJ 89, 1155; 91, 522 and 808; Elias + ApJ 289, 141); IUE spectra of a few OB stars in M31 and M33 surprisingly show winds like in the Magellanic Clouds (Massey + AJ 90, 2239).

3. "Quiet" Massive-Star Formation (SF)

Tracers of SF have been summarized by Lequeux (Spectral Evol. Gal., 57) and comprise direct star counts, colors, far-UV radiation, Balmer line emission, far-IR radiation, radio continuum flux, and even soft X-rays. There are good correlations between these quantities, e.g. far-IR/Hα (Dennefeld in Star-Forming Dwarf Gal. p. 351), far-IR/radio continuum (Helou + ApJ 298 L7; Gavazzi + ApJ 305, L13; Kunth + in Star Forming Dwarf Gal. p 331), soft X-rays/radio continuum althrough part of the X-rays can come from an old population (Fabbiano + ApJ 296, 430; see also Trinchieri + ApJ 290, 96; Palumbo ApJ 298, 259; Cox + ApJ 304, 657; Fabbiano + ApJ 315, 46). Strangely, Turner + (ApJ 313, 644) find too much Balmer line emission in the nucleus of M83 for the observed radio flux. Other correlations are less straightforward to interpret e.g. far-IR/blue light (Iyengar + AA 148, 43; Thronson + ApJ 311, 98), Hα/blue light (Phillips + MN 217, 435) or FIR/2 μm light (other tight correlation between SF (measured by the far-UV flux) and HI has been studied by Donas + (AA 140, 325 and in prep.) but Kennicutt + (AJ 89, 1279) find only a loose correlation between Hα and HI while Rengarajan +(AA 165, 300) shows a good correlation far-IR/HI. SF seems to be proportional to HI mass in M33 (Nakai + PASJ 36, 313). There appears to be a HI surface density threshold for SF (Skillman + AA 165, 45; Guideroni AA 172, 27), and the SF/HI ratio seems somewhat type-dependent, decreasing from Sb to I (Mochkovitch + AA 137, 298; Comte, in Spectral Evol. Gal. p. 81). SF seems also rather tightly correlatedto molecular gas as expected (Rickard + AJ 89, 1520; 90, 1175; Israel + ApJ 283, 81; Sanders + Ap.J. 298, L31; Young + ApJ 304, 443). Chini +(AA 166, L8) find a good correlation between warm dust emission in the far-IR and the total amount of interstellar matter by the 1.3 mm dust emission.

Relations between SF and morphology have been examined by various authors. McCall + (ApJ 311, 548) and Elmegreen + (ApJ 311, 554) find no difference between flocculent and grand-design galaxies. Only strong bars and/or rings enhance star formation (Hawarden + MN 221, 41P; Prieto + AA 146, 297; Hummel + AA 172, 32). The time history of SF in galaxies, mainly I, has been touched upon by e.g. Gallagher + (Ann. Rev. AA 22, 37; ApJ Suppl. 58, 533) and Sandage (AA 161, 89) who confirm that it is does not decrease appreciably with time in the I contrary to the S (see e.g. Isserstedt + AA 167, 11). The proportionality of SF rate to the mass of gas favors self-regulated models like those of Dopita (ApJ 295, L51 and preprint), Shore + (ApJ 316, 663), or Tanaka + (Ap. Sp. Sci. 119, 207); see also Scalo + (ApJ 301, 77) and Cox (ApJ 288, 465).

Extensive surveys of HII regions have been made in several spirals by Viallefond + (AA 154, 357), Courtès + (AA 174, 28), Bonnarel + (AA Suppl. 66, 149) and Kaufman + (ApJ in press) while Hodge (PASP 98, 1095; IAU Symp 116) reports on stellar associations. Detailed properties of individual HII regions are discussed by Viallefond + (ibid.), de Gioia Eastwood (ApJ 288, 175) and Skilmann (ApJ 290, 449); see also Kennicutt (ApJ 287, 116) and Kennicutt + (PASP 96, 944). Their internal velocity dispersion is studied by Roy + (ApJ 300, 264), Hippelein (AA 160, 374), Chu (ApJ 311, 85) and Arsenault + (AJ 92, 576).

4. Chemical Abundances and Evolution

Spectrophotometric data on HII regions and planetary nebulae have been gathered by Stauffer (AJ 89, 1702), Dufour + (NASA CP 2349 - 107), McCall (ApJ Suppl. 57, 1), Stasinska + (AA 154, 352, Peimbert + (AA 158, 266), Dufour (PASP 98, 1025), Fierro + (PASP 98, 1032), Garnett (PASP 98, 1041), Campbell + (MN 223, 811), Zamorano + (AA 170, 31), Jacoby + (ApJ 304, 490), etc. and their interpretation in terms of abundances discussed by McCall (ibid) and Dopita + (ApJ 307, 431; application to M101 in Evans + ApJ 309, 544). The very low abundances in IZw 18 are still unique (discussion in Kunth + ApJ 300, 496). Correlations between elemental abundances are: excellent for Ne/O (Vigroux + AA 172, 15); poorer for S/O, a difficult elements, probably positive but loose for He/O, hence one difficulty in determining the primeval He abundance (Pagel in Paris Conf. on Nucleosynthesis; Peimbert +, preprint; see also Davidson + ApJ Suppl 58, 321); N independent on O at low metallicities with fluctuations (primary?) and secondary at low metallicities; C more or less like N. Models based on recent nucleosynthesis recipes (see Truran, in Stellar Populations p. 149) account reasonably well for all these features (Wyse + ApJ 296, L1; Matteucci + MN 217, 391; 221, 911; Tosi + MN 217, 571; Diaz + AA 158, 60) provided that infall or galactic winds are included (see also Arimoto + AA 164, 260 and Clayton + ApJ 307, 411).

5. Environmental Influences

The influence of the environment on the HI content of galaxies is well established: for early work see Haynes +(Ann. Rev. AA 22,445): S and SO galaxies in the center of dense clusters are statistically HI-deficient, probably due to stripping by the intergalactic medium (Giovanelli + ApJ 292, 404; several papers in The Virgo Cluster of Gal.; Huchtmeier + AA 149, 118; Guideroni + AA 151, 108; Chincarini + AA 153, 218; Vigroux + AJ 91, 70; Haynes + ApJ 306, 466; Chamaraux + AA 165, 15; Giraud + AA 167, 25; Warmels, in prep.) However the molecular component is not affected (Kenney + ApJ 301, L13). Gavazzi + (ApJ 294, L89; 310, 53) show that galaxies have a higher SF rate in clusters, even HI-poor S. Moss (Starbursts and Evol.) find Hα-emitting galaxies more frequent in rich clusters and Petrosian + (AA 163, 39) show that Markarian galaxies are preferably in dense clusters. All this may be the effect of encounters. Clusters also contain an excess of low-surface brightness or red galaxies (Giuricin + AA Suppl 62, 157; Galagher + AJ 92, 557; van der Hulst + AA 177, 63): this may by the final result of encounters. Burnstein + (ApJ 305, L11) find that the mass distribution in S is a function of environment. Bosma (AA 149, 482) however warns about attributing problems with the IR surface brightness/HI line width to environmental effects.

6. Starbursts

The discovery of very strong starbursts in galaxies is one of the major events in recent years. Although some cases were known before, far-IR observations with IRAS have shown how frequent and strong these starbursts can be; the energy output can be 100 times larger than normally (Emmerson + Nature 211, 237; Houk + ApJ 290, L5; Antonucci + AJ 90, 2203 and 91, 56; Soifer + ApJ 283, L1 and 303, L41; Fairclough, MN 219, 1P; Hill + ApJ 316, L11). As expected the dust that re-radiates the energy is hotter than usual and the flux is very strong from a few μm to a few hundreds of μm (Lawrence + ApJ 291, 117; Sekiguchi ApJ 316, 145, etc.). All SF tracers described previously can be used to find starburst galaxies: colors (Belfort + AA 76, 1; many Markarian and KISO galaxies are starburst, see e.g. Deutch ApJ 306, L11); line emission, including Lyman α (Djorgovski in Starbursts and Gal. Evolution; Deharveng in Starforming Dwarf Gal. p 431); far-UV (Hartman + ApJ 287, 487; Walsh + MN 220, 453); radio continuum (Maehara + PASJ 37, 451; Karoji + AA 155, 43), of course IR radiation, and X-rays (Fabbiano + ApJ 286, 491). Starburst galaxies have strong CO emission, with good CO/far-IR and CO/radio relations (Young + ApJ 287, L65). Very often the starburst is confined to the central regions and offers interesting morphology (rings, etc. also in CO): eg. NGC 3310 (Telesco + ApJ 284,544), NGC 2903 (Wynn-Williams + ApJ 290, 108) Arp 220=IC 4553 and NGC 6240 (Rieke + ApJ 290, 116; Neugebauer + AJ 93, 1057; Scoville + ApJ 311, L47), NGC 1068 (Myers + ApJ 312, L39; Telesco ApJ 282, 427; Wynn-Williams + ApJ 297, 607; Evans + ApJ 310, L15; Planesas + AA, in press); see also Blitz + ApJ 311, 142.

Most far-IR emitting galaxies are believed to be starburst (Elston + ApJ 296, 106; Moorwood + AA 160, 39) but the distinction with Seyferts is not always easy. Starburst blue compact dwarfs can be Seyfert (Kunth + AJ 93, 29) and Seyferts can also show starbursts (Rodriguez-Espinosa + 309, 76 and 555; Wilson + ApJ 310, 121; Heckman in starbusters and Gal. Evol.; Weedman ApJ 291, 72 for NGC 1068). Arp 220 is definitley an edge-on Seyfert (Norris MN 216, 701; de Poy + ApJ 307, 116 and 316, L63) and NGC 4418 might be similar (Roche + MN 218, 19P). Merging galaxies (mergers) can produce starbursts, Seyfert nuclei or both (Sanders + ApJ 312, L5; Byrd + AA 166, 75 and 171, 16; Netzer + AA 171, 41; Hutchings + AJ 92, 6 and 14; Joseph in light on dark matter p. 47 and in starbursts and Gal. Evol.). The presence of shocks yielding excited H_2 is not a good distinction criterion (Joseph + Nature 311, 132). Moorwood (AA 166, 4) notices that the 3.28 µm feature is rare in Seyferts, while Rieke + (ApJ 304, 326) and Rowan-Robinson (Light on dark matter p. 421 and Starbursts and Gal. Evol.) propose interesting far-IR criteria.

It is now clear that galaxy interactions trigger starbursts. This can be seen statistically (Altschuler + AJ 89, 1531; Joseph + MN 209, 111; Lonsdale + ApJ 287, 95; Keel + AJ 90, 708; Sanders + ApJ 305, L45; Young + ApJ 311, L17; Kennicutt + AJ 93, 1011; Brink in Spectral Evol. of Gal, although Lawrence + (MN 219, 687) disagree), or in individual cases (van der Hulst + AA 150, L7; Urbanik + AA 152, 291; Hummel + AA 155, 151 and 161; Lester + ApJ 302, 280; Telesco + ApJ 302, 632; Boissé + AA 173, 229). Ring galaxies fall in the same category (Bonoli AA 174, 57; Appleton + ApJ 21, 566; Wakamatsu + ApJ 315, L23); star formation often occurs in both members of a pair of interacting galaxies (Shaver + AA 148, 143; Kollatschny + AA 163, 31; Madore, in Spectral Evol. of Gal. p. 97). Extreme cases are mergers (Joseph + MN 214, 87) wich may become radiogalaxies (Heckman + ApJ 311, 526); Arp 220 and NGC 6240 might be mergers (Fried + AA 152, L14; Joy + ApJ 307, 110). Various cases are described by Graham + (Nature 310, 213), Bergvall + (AA 149, 475), van Breugel + (ApJ 311, 58) and Joy + (ApJ 315, 480). Mk 171 has been particulary well studied (Augarde + AA 147, 273; Telesco + ApJ 299, 896; Sargent + ApJ 312, L35) and there is a suggestion that only massive stars are formed (see also Olofsson + AA 137, 327). Harwit + (ApJ 315, 28) and Larson (in Starbursts and Gal. Evol.) propose simple models for starbursts in collisions. Jets may also trigger starbursts (Tresch-Fienberg + ApJ 312, 542; Reay + MN 218, 13P) van Breugel (ApJ 293, 83).

Blue compact dwarfs (BCD), clumpy I and Amorphous galaxies are special cases of starbursts. BCDs have been discussed above but see also Gonghalekar + (MN 209, 59), Bergvall (AA 146, 269) and Wynn-Williams + (ApJ 308, 620). Clumpy I are discussed by Heidman (IAU Symp. 116, p 599) see also Klein + (AA 154, 373) and Yin (Sci. Sin. A. 28, 1090). Amorphous galaxies show SF over their whole surface (Hunter + ApJ 303, 171; Arp + AJ 90, 1163; Bothun AJ 91, 507; Melnick + AA 149, L24; Lamb + ApJ 291, 63; Noreau + AJ 93, 1045).

There is abundant literature concerning the two best-studied pure starburst galaxies: M82 (Jaffe + ApJ 285, L31; Weliachew + AA 137, 335; Olofsson + AA 136, 17; Young + ApJ 287, 153; Unger + MN 211, 783; Jones + ApJ 285, 580; Watson + ApJ 286, 144; Houck + ApJ 287, L11; Kronberg + ApJ 291, 693; Seaquist + ApJ 294, 546; Dietz + AJ 91, 758; Lutgen + ApJ 311, L51; Lo + ApJ 312,574; Le Van + ApJ 312, 592; Duffy + ApJ 315, 68; Heckman + AJ 92, 276; Mc Carthy + AJ 92, 264) and NGC 253 (Mc Carthy + ibid.; Hummel + AA 137, 138; Young + ApJ 289, 129; Turner ApJ 299, 312). These galaxies and the most powerful starburst galaxies are favorite places to detect galactic-scale winds (models by Chevalier + Nature 317, 44 and Schiano ApJ 299, 24) and molecules other than CO (Henkel + AA 150, L25; Seaquist + ApJ 303, L67). Strong starburst galaxies often show HI, OH and other molecular absorptions due to the strong concentration of gas and the intense radio continuum, and also OH and H_2O megamasers (at least for OH) from IR pumping by the intense radio field (Schmeltz + ApJ 315, 492; AJ 92, 1291; Hashick + Nature 314, 144; Bann + Nature 315, 26; ApJ 293, 394; 298, L51; 305, 830; 313, 102; Norris + MN 213, 821; 221, 51P; Bottinelli + AA 151, L7; Kazès + AA 152, L9 and in prep.; Unger + MN 220, 1P; Martin + ApJ 308, L7; Claussen + ApJ 308, 592; Gardner + MN 221, 537; Nakai + PASJ 38, 603; Henkel + AA 168, L13).

3. Galactic Dynamics
(P.C. van der Kruit)

Much progress has been made in the area of structure and dynamics of elliptical galaxies. A number of papers have been published on Schwarzschild's method of constructing model galaxies by populating stellar orbits and finding self-consistent models through linear programming techniques. The method itself and results are discussed and presented by Vandervoort (ApJ 287, 475) and Richstone and Tremaine (ApJ 286, 27). Characteristics of orbits are being discussed by Robe (AA 142, 351), Davoust (AA 156, 152) and Levison + (ApJ 295, 349).

A major new development is constituted by the work of de Zeeuw (MN 216, 273) who showed that potentials are separable in Stäckel potentials and that all orbits then have three isolating integrals. This has been followed up by de Zeeuw (MN 216, 599; MN 215, 731) and the Zeeuw + (MN 221, 1001; 215, 713; ApJ 317, 607).

Construction of models for elliptical galaxies by and studies of appropriate distribution functions can be found in Newton (MN 210, 711), Bertin + (AA 137, 26) and Stiawell + (MN 217, 735). Dynamical instabilities and perturbed galaxy models have been studied by Barner + (ApJ 300, 112), Aguilar + (ApJ 307, 97), Merritt + (MN 217, 787)Gerhard (AA 151, 279) and Martinet + (AA 173, 81).

A major issue is the traxiality of elliptical galaxies and the anisotropy of the velocity distributions. Models and distribution functions can be found in Merrit (MN 214, 258; AJ 90, 1029) and for boxshaped ellipticals in Petrou (MN 226, 111). The effects of a black hole in the centre have been investigated in Gerhard and Binney (MN 216,467) and Norman + (ApJ 296, 20). Tests for triaxiallity are reported by Barney (MN 216, 767) and Bacon (AA 143, 84). The corresponding question of mass-to-light ratio M/L is addressed by Levison + (ApJ 295, 340) and Richstone + (AJ 92, 72). Dissipative formation of elliptical galaxies has been discussed by Carlberg (ApJ 286, 403; 286, 416; 300, L1), including effects of dark halos. Constraints on dark halos from shells around elliptical galaxies (for a review see Anthanassoula + Ann. Rev. AA 23, 147) have been derived by Hernquist + (ApJ 312, 1).

The dynamics of bulges of spiral galaxies is also increasingly better understood now that detailed models have been constructed and tested against observation (Jaris and Freeman ApJ 295, 314 and 324). Binney and Petrou (MN 214, 449) derive distribution functions appropriate to box-shaped bulges. The effects of disks on spheroidicals and formation scenarios for disk galaxies have been discussed by Binney + (MN 218, 734) and Barnes + (MN 211, 753). There is also significant progress in the dynamics of galactic disks now that stellar velocity dispersion can be measured and stability studied observationally (v.d. Kruit and Freeman, ApJ 303, 556). Distribution functions and their evolution have been studied by Villumsen (ApJ 290, 75; 295, 388). The effects of massive black holes in the halos on disk kinematics is investigated by Lacey and Ostriker (ApJ 299, 633), while dynamical evolution due to transient spirals is studied in the models of Caldberg and Sellwood (ApJ 292, 79). Stability questions for our galaxy are adressed by Sellwood (MN 217, 127). Numerical three-dimensional simulation of disks in massive halos are presented by Miller (Celest. Mech. 37, 307). Carlberg + (ApJ 298, 486) describe simulations of dissipative spiral galaxy formation. Three-dimensional orbits and consequences have been studied by Contopoulos + (Celest. Mech. 37, 387; 38, 1; AA 161, 244; 153, 44). Recently Athanasoulla + (AA 179, 23) used disk stability and kinematics considerations in constructing mass models for spiral galaxies.

Lubow + (ApJ 309, 496) studied the dynamics of both stars and gas in spiral density waves, while Hausman + (ApJ 282, 106) presented models for a cloud-derivated gas components in disks with density waves. Stellar 4/1 resonances in disks and the effects on spiral depaumis are discussed by Contopoulos + (AA 155, 11; see also comm. Astrophys. 11, 1). The origin of spiral instabilities was investigated from the point of view of gas accretion (Sellwood + ApJ 282, 61) and of bar potentials (Schwarz, MN 212, 677; MN 209, 93). Athanassoula and Sellwood (MN 221, 195; MN 221, 213) have described instabilities in model disks with a view at stability and bar-,or spiral responses.

Schwarzschild (ApJ 311, 511) has studied the orbit families in a particular model bar and found them restricted to box orbits. Michalodinitrakis + (AA 150, 83) also studied orbits in three dimensions and Pfenniger (AA 134, 373; 141, 171; 150, 97; 150, 112) has addressed the question of resulting velocity fields, instabilities and bulge dynamics. Teuben and Sanders (MN 212, 257) define dynamical rules to which realistic barred galaxy models conform. Weinberg (MN 213, 451) studied the angular momentum transfer between bar and halo.

Dynamical studies of galactic warps are producing constraints on their possible origin. Sparke (MN 211, 911) has produced models that seem to enclude bars and suggests weakly barred retrograde figure-rotating dark halos.

Interest in polar rings is also increasing. Whitmore + (ApJ 314, 439) find weak constraints on dark halo flattening. Coupled orbital characteristics can give simular constraints (Katz + AJ 89, 975). The stability appears related to its self-gravity in models by Sparke (MN 219, 657). Binney + (MN 226, 144) also discuss the flattening of dark halos.

There have been a number of papers addressing the question of dynamical friction on galaxy satelites and the corresponding orbit decay and capture (Weinberg, ApJ 300, 93; Tremaine + MN 209, 729; Quinn + ApJ 309, 472; Byrd + MN 220, 619; Bontekoe + MN 224, 349).

There is major interest in possible revisions of Newtonian gravity to explain flat galaxy rotation curves without dark matter (Milgrom, ApJ 287, 571; Sanders, AA 136, L21; AA 154, 135). Futher discussion has been given by Kuhn + (ApJ 313, 1), while Christodoulou + (ApJ 307, 449) and Hernquist + (ApJ 312, 17) show apparent inconsistencies with observed warps in spirals and shells in ellipticals.

4. Groups and Clusters of Galaxies
(G.A. Tammann)

Deeper and deeper galaxy surveys reveal larger structures. The scale length over which galaxies are distributed uniformly has not been reached yet. There is no question that the clustering of galaxies on all scales contains still the most decisive clues for galaxy information. Clusters are also the best sites for studying galaxy evolution, i.e. evolution in the universe in general. The clustering of galaxies and its effect on the Hubble expansion field offer also a unique chance for large amounts of hypothetical non-baryonic mass wich might close the universe (cf. IAU Symp. 117: Dark Matter in the Universe). The cosmological aspects are covered in the Report of Commission 47. Yet the detailed understanding of nearer groups and clusters lies at the basis of the understanding of the large-scale structure as well as of the cosmogony of individual galaxies.

The following Conference Proceedings have appeared since the last report: *Clusters and Groups of Galaxies*, Trieste, 1983 (*cited here: Clusters and Groups*); The Virgo Cluster, Garching, 1984; Galaxy Distances and Deviations from Universal Expansion, Kona-Hawaii, 1986/cited here: Galaxy Distances). Not available at the time of writing are the Proceedings of: IAU Symp. 130: Evolution of Large-Scale Structures in the Universe, Balatonfüred, 1987; 3rd IAP Astrophysics Meeting: High Redshifty and Primeval Galaxies, Paris, 1987: as well as the lectures (by A. Fabian, M. Geller, and A. Szalay) of the Saas-Fee Course: Large-Scale Structure of the Universe.

I. THE LOCAL GROUP

Distances to LG galaxies have been considerably improved by various methods, i.e. RR Lyr stars (van den Berg and Pritchet) and novae (Cohen) in M31, population II giants in M31 and M33 (Mould and Kristian), and most importantly infrared photometry of Cepheids (Weech +, McAlary +, Madore +, Freedman +, Visvanatahan, - for detailed references see IAU Symp. 124, 151), the latter method being exceptionally sensitive to absorption and metallicity effects. The distances to LMC and SMC are reviewed by Feast (Galaxy Distances p 7). A mass of the LG of 3.10^{12} $M_\odot$ and hence - M/L_B = 13-20 has been determined by Sandage (ApJ 317, 557) from its decelerating effect on very nearby field galaxies and from the Kahn-Woltjer paradox; the value is compatible with Lynden-Bell (IAU Symp 106, 461). Mishra (MN 212, 163) argues that the mass of the Milky Way is at least half of that of M31.

The motion of the Sun relative to the centroid of the LG has been redetermined by Richter + (AA 171, 33). An X-ray survey of the LG was discussed by Helf and (PASP 96, 913).

II. GROUPS

Galaxy groups were reviewed by Geller (Clusters and Groups p 353) and Vennik (AN 307, 157). Their M/L_B ratios of 220 (see also Heisler + ApJ 298, 8; Mezzetti + AA 143, 188) and 65, respectively, show a clear discrepancy with the LG (cf. Trimble, Nearly Normal Galaxies p 313), perhaps because of the inclusion of unbound groups (the values here are reduced to H_0 = 50). Schneider + (AJ 92, 742) conclude that the mass determined from the galaxies'rotation is sufficient to bind small groups; this is clearly the case for compact groups (Williams + ApJ Suppl. 63, 265). Byrd + (ApJ 289, 535) take unbound group members as the explanation of apparent non-Doppler redshifts in groups (cf. Arp + ApJ 291, 88). Spiral galaxies in groups seem to have normal HI content (Huchtmeier, Clusters and Groups p 221; Giuricin + AA 146, 317). Optical properties of group members may depend somewhat on compactness (Guiricin + AA Suppl 62, 157). X-ray emitting gas has been detected in the group elliptical NGC 5846 (Biermann + Clusters and Groups p 395); some of the hot gas found in three groups by Bahcall + (ApJ Lett 284, L29) may lie in the ultragroup region. The discovery of a large, intergalactic HI cloud in the Leo group by Schneider + (1983) has drawn considerable interest; it is now interpreted as a ring surrounding two galaxies (Schneider ApJ Lett 288, L33). Dickel + (Clusters and Groups p 389) suggest an HI cloud also in Seyfert's group. Narrow-angle tailed radio galaxies in poor groups are discussed by Burns + (BAAS 18, 707). ^{12}CO emission in the UMa group is taken as evidence for galaxy interaction (Odenwald ApJ 310, 86). Group rotation (Williams ApJ 311, 25) and preferential orientation of group members (Rosino + Astrofizika 19, 834) are suggested in individual cases; for a ring-shaped group see Danks + (AA 139, 455). Karachentseva + (AA Suppl. 60, 213) published an atlas of dwarf galaxies in the M81 group. Cepheid distances have become available for two group members, NGC 300 (Graham AJ 89, 1332; Freedman, Galaxy Distances p 21) and tentatively M101 (Cook + ApJ Lett 301, L45). A catalogue of 100 compact groups (Hickson + Clusters and Groups p 367) may contain ~50% of chance superpositions (Mamon ApJ 307, 426). The effect of gravitational lensing is discussed by Hammer + (AA 155, 420). The time scale of dynamical evolution of (compact) groups seems amazingly short (Williams ApJ 290, 462; Williams + ApJ Suppl. 63, 265; Barnes MN 215, 517; Navarro + MN 228, 501). Fricke + (Mitt Astr. Ges. 67, 383) find Seyfert and AGN galaxies to lie preferentially in compact groups.

III. THE VIRGO CLUSTER

Much work has been devoted to the Virgo cluster. A complete catalogue of morphologically selected members to B < 18^m has been published, the majority of them being dEs (Bingeli + AJ 90, 1681). A large body of redshifts is available for the cluster members, mainly from the work of Huchra (cf. The Virgo Cluster p.181). Surface distribution, type segregation (cf. also Salpeter, *Galaxy Distances* p.159) with a pronounced lack of Im's towards the cluster center, and subclustering are discussed; even the E core of the cluster seems dynamically young (Bingeli + AJ 94, 251). In the outerpart spirals are still falling in (Tully + ApJ 281, 31). As compared to the field, cluster spirals are HI deficient (e.g. Balkowski + The Virgo Cluster p.37; Giovanelli ibid.p.67; Huchtmeier ibid.p.23; Warmels ibid.p.51), ram pressure (van Gorkum + ibid. p.61) and turbulent viscous stripping (Haynes + ApJ 306, 466) being proposed as the cause. Both these mechanisms are compatible with the normal CO content of these galaxies (Kenny + ApJ Lett 301, L13). HI deficiency is accompanied by color (Kennicutt + The Virgo Cluster p.91 and 227; Guideroni AA 151, 108) and geometrical (MacGillivray + The Virgo Cluster p.217) pecularities of the cluster members; their present star formation rate from IRAS data is lower than in their field counterparts (de Jong, The Virgo Cluster p.111). The radio continuum is field-like except in the very core; M87 may be a wide-angle tail source (Kotanyi The Virgo Cluster p.13). Also the X-ray emission of Virgo and field galaxies is comparable, except for M87 wich contains $\sim10^{12}$ $M_\odot$ of hot gas, comparable to NGC 4696 in the Centaurus cluster (Forman + The Virgo Cluster p. 323). The center of very extended, hard X-ray component may possibly coincide with the cluster center of M87 (Smith + ibid. p.345).

While Bothun + (AJ 90.697) suggest Virgo dEs to be stripped dwarf irregulars, Binggeli (Star-Forming Dwarf Galaxies p.53) finds this transaction to be improbable. Hoffman + (preprint) find no evidence for dIm's being distributed more uniformly than spirals; this would be expected from biased galaxy formation (Dekel + ApJ 303, 39). Even in the field the number ratio low/high surface brightness galaxies seems to remain constant (Bothun + ApJ 308, 510; Binggeli, Sandage, and Tarenghi, work in progress; however Davis + ApJ 299, 15).

The luminosity function (LF) of E and S galaxies is roughly Gaussian, while the dE's have an flatter LF (Sandage + AJ 90, 1759). The shape of the LFs, separated according to Hubble types, is nearly the same in the Coma cluster and in the field, however the LF over all types changes with the type mixture, i.e. with the surrounding galaxy density (Binggeli, Nearly Normal Galaxies p.195). Several independent distance indicators seem to converge towards a Virgo cluster distance near $(m-M)^0 = 31.6$, i.e. globular clusters (van den Berg + AJ 90, 595), novae (Prichet + ApJ 318, 507), the L/σ relation of spiral bulges (Dressler ApJ 317, 1), and the Tully-Fischer relation of a nearby complete sample of 81 Virgo spirals (Kraan-Korteweg + Basel Preprint No. 26), while supernovae Ia (Tammann, IAU 124.151) may indicate a somewhat higher value; cf. however de Vaucouleurs (The Virgo Cluster p.413).

IV. OTHER CLUSTERS OF GALAXIES

The Fornax cluster's population was studied by Caldwell (AJ in press); a survey on a large-scale plates is underway (Sandage and Ferguson). Surface photometry is carried out by Phillips (Cluster and Groups p.183). Photometry of SO members is provided by de Carvalho + (AA 149, 449). Redshifts were determined by Richter + (AA Suppl 59, 433).

The structure and dynamics of the Coma cluster were reviewed (Peach, Clusters and Groups p.89; Schipper PhD thesis). Millington + (MN 221, 15) adopt a model of constant velocity anisotropy to derive a M/L ratio of 240. The cluster mass is a few times 10^{15} $M_\odot$ and M/L roughly 100 (Gerbal + Clusters and Groups p.147; The + AJ

92, 1248). This is a good agreement with the mass inferred from X-ray data (Kriss, Clusters and Groups p.313; Cowie + ApJ 317, 593). For three groups within the Coma-A1367 supercluster Williams (Clusters and Groups p.375) derives M/L_B = 30-40. Fichett + (preprint) suggest the cluster to be dynamically young. The specific energy of the intracluster medium is studied by Gerbal1 + (AA 158, 177). The radial X-ray profile of the cluster is analyzed by Chanan + (ApJ 287, 89). Branduardi + (Space Sci Rev 40, 647) find an excess of X-ray sources in the cluster background. Upper limits on the far-UV emission from the cluster center are set by Holberg + (ApJ 292, 16). Cordey (MN 215, 437) discusses two extended radio sources in the cluster. Gavazzi + (ApJ 310, 53) find that E/S0 galaxies in the cluster are more likely to be radio sources than in the field; the effect is much more pronounced for spirals; the authors conclude that the same mechanism wich causes the HI deficiency of spirals triggers also bursts of star formation. Blue disk galaxies in Coma, similar to those observed in high-redshift clusters, require a mechanism for enhanced stare formation (Bothun ApJ 301, 57). Several determinations of the distance modulus difference Coma-Virgo yield values of $\Delta(m-M)^0$ = 3.6-4.0 (Dressler ApJ 281, 512 and 317, 1; Vader ApJ 306, 390; Lucey MN 222, 417; Kraan-Korteweg + Basel Preprint No 26).

The Centaurus cluster may form together with the Hydra I cluster and clustering in Atlas a large supercluster (Hopp + AA 61, 93; da Costa + AJ 91, 6). This is of great interest because the "big attractor" is to be expected in this general direction in order to explain the MWB dipole in conjunction with our Virgocentric flow (see below); of course the motion towards the MWB pole could also be due to more than one attractor. Lucey + (MN 221, 453 and 222, 427) find in Centaurus two galaxy concentrations at 3000 and 4600 km s^{-1}, but believe them to be at the same distance, contrary to Lynden-Bell + (preprint). In either case the finding requires large streaming velocities.

The Hydra cluster is in several respects similar to Virgo, but apparently more evolved, perhaps it lies in a void and infall of spirals has ceased (Richter, The Virgo Cluster p.427). The structure of the Perseus (super-) cluster has been investigated by Focardi + (AA 136, 178), Egikyan + (Astrofizica 23, 5), Tanaka (Publ Astr Soc Jpn 37, 481), and Giovanelli (BAAS 17, 581), and that of the Cancer cluster by Bicay + (BAAS 17, 578) and Perea + (MN 222, 49); for A149 see Nemiroff + (AJ 90, 163) and Mazure (AA 157, 159). Studies of non-random orientations of spiral galaxies in the Virgo complex remain inconclusive (MacGillivray + AA 15, 269; Anderson + Clusters and Groups p.63; Flin + ibid.p.65). Dodd + (Ap Space Sci 123, 145) find galaxy alignment in the Shapley-Centaurus cluster. Flin (Clusters and Groups p.163) suggests preferred ellipticities in individual clusters. Large-scale alignment of neighboring clusters, i.e. the Binggeli effect, was questioned by Stubble + (AJ 90, 582), see however Rhee + (AA 183, 217). Luminosity segregation in 0004.8-3450 is interpreted as the effect of cannibalism (Capelato + Ap Space Sci 108, 363). Wakamatsu + (AJ 92, 700) have discussed the interacting ring galaxies in the Hercules cluster. The fraction of emission line galaxies in A634 is surprisingly high (Stepanyan Astrofizica 21, 245), while Dressler + (ApJ 288, 481) find from a large sample that the emission line fequency is much higher in field galaxies

Photometry was provided in A1213 (Egikyan + Astrofizika 21, 21) and A2052 (Couture + J R Astr Soc Can 78, 211); for other clusters see Le Fèvre + (AA Suppl 66, 1), Yamagata + (Publ Astr Soc Jpn 38, 661; Ann Tokyo Obs Ser II 21, 31; Ap Space Sci 118, 459), Melnick + (AJ 89, 1288), and Couch + (ApJ Suppl 56, 143); for 175 brightest cluster galaxies see Hoessel + (AJ 90, 1648). The luminosity functions in several Abell clusters were derived by Oemler + (AJ 93, 519) and Lugger (ApJ 303, 535). HI and radio continuum mapping of the Hercules cluster was carried out by Salpeter + (ApJ 292, 426) and Dichey (ApJ 284, 461). Nonthermal radio sources in clusters were reviewed by Fanti (Cluster and Groups p.185). Faraday rotation measures of background radio sources in A2319 show a large-scale magnetic field in the cluster (Valée + AA 156, 386).

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Of great interest is the discovery of gigantic luminous, somewhat knotty arcs in A2218 and 2242-02 (Lynds + BAAS 18, 1014) and in A370 (Soucail + AA 172, L14).

A distance of the Hercules cluster has been published by the Vaucouleurs + (ApJ 297, 23) and Buta + (ApJ Suppl 62, 283). The distances to ten clusters at $4000 < v < 11000$ km s^{-1} (Aaronson + ApJ 302, 536) have statistically been improved by Bottinelli + (AA 181, 1) and Kraan-Korteweg + (ApJ in press).

A compilation of cluster redshifts is given by Schmidt (AN 307, 69), see also Postman + (AJ 90, 1400). 418 high-redshift clusters have been found in a systematic survey by Gunn + (ApJ 306, 30). The automated detection of clusters is described by Dodd + (AJ 92, 706). A much needed test of the reliability of the Abell catalogue has been provided from clusters in the Shane-Wirtanen catalogue (Shectman ApJ Suppl 57, 77) with somewhat alarming results. Viral masses of clusters, in addition to those already mentioned, have become available for A2197 and A2199 with $M/L \sim 100$-250, but the double cluster method indicates $M/L \sim 50$ (Gregory + ApJ 286, 422 and 305, 580). If the Perseus cluster is a flat system seen nearly edge-on its mass corresponds to $M/L \sim 50$ (Tanaka Publ Astr Soc Jpn 37, 481). A value of $M/L = 68$ is found for the poor cluster MKW 4 from the viral theorem and X-ray data (Malamuth + ApJ 308, 10). Valtonen + (ApJ 303, 523) find groups and clusters largely unbound and hence still smaller M/L values.

An illuminating review on the evolution of cluster galaxies has been given by Dressler (Ann Rev Astr Ap 22, 185; Clusters and Groups p.117). More recent investigations have concentrated mainly on three questions: 1) Are cluster galaxies HI-deficient? The answer is positive (Giovanelli + ApJ 292, 404), positive for early-type spirals only (Dressler ApJ 301, 35), respectively negative (Bothun + ApJ291, 586). Besides gas stripping enhanced star formation (Gavazzi + ApJ Lett 294, L89; Tammann, Star-Forming Dwarf Galaxies p.41) may be a cause of gas deficienty. 2) Have galaxies in very distant clusters higher star formation rates than locally? The answer is positive (Butcher + ApJ 285, 426 and Nature 310, 31; Schild ApJ 286, 450; Lavery ApJ Lett 304, L5; Ellis + MN 217, 239), occasionally (Dressler + Space Telsc Sci Inst Prepr 130, 65), marginally (Thompson ApJ 300, 639 and 306, 384, Sharples + MN 212, 687; Couch + MN 213, 215; Dressler + ApJ 294, 70), restricted to a few galaxies (Lilly + MN 217, 551), and negative (Laurikainen + New Aspects of Galaxy Photometry p.309). Tyson (AJ 92, 691) proposes enhanced star formation in galaxies near to QSOs. 3) How do first-ranked cluster galaxies evolve? Brightest cluster galaxies are not the extreme members of a statistical population (Bhavsar + MN 213, 857; however Morley PASP 96, 874). If they are cDs they are $\sim 0^m.5$ brighter than "normal" first-ranked galaxies (Lugger ApJ 286, 106). Hoessel + (AJ 90, 1648) find a strong correlation between the structure and luminosity of the brightest cluster galaxies. Their specific structural properties suggest environmental effects (Schombert ApJ Suppl 60, 603) like bound satellites (Cowie + ApJ Lett 305, L39), accretion flows (Lindblad + New Aspects of Galaxy Photometry p.337) or mergers (Tonry AJ 90, 2431; Merrit ApJ 289, 18; Malamuth ApJ 291, 8; Hoessel + ApJ 293, 94). But globular clusters contradict the merging of spirals to form ellipticals (van den Berg, Cluster and Groups p.139; cf. also Muzzio + ApJ 285, 7).

The intracluster medium has been investigated by means of radio tail galaxies (O'Dea + AJ 90, 927 and 954) and distorted radio sources (Hanisch + AJ 90, 1407). extended Hα feature around NGC 4438 is interpreted as due to the bow-shoch caused by the motion of the galaxy in the medium (Chincarini + AA 153, 218). The X-ray emission of clusters requires cooling flows (Arnaud + MN 21, 981; Jones + Clusters and Groups p.319; Bertschinger + ApJ Lett 306, L1; for reviews see Fabian + Nature 310, 733; Fabian, Mitt Astr Ges 65, 123; Steward + ApJ 285, 1) Hendriksen + (ApJ 292, 441) find the original isothermal model to be non-physical (see however Gerbal + AA 146, 119; Miller MN 220, 713). The X-ray properties of individual clusters are discussed by many authors, e.g. of the clusters in Perseus (Branduardi-Raymont + Adv Space Res 5, 133) and Pegasus (Canizares + ApJ 304, 312); typical X-ray properties of clusters are discussed by Kowalski + (ApJ Suppl 56, 403), Ulmer + (Clusters and Groups p.307), Beers + (ApJ 283, 33), Kalinkov (New Aspects of Galaxy Photmetry p.331), and Quintana + (AJ 90, 410). Star formation is an accreting cluster is found only in the Perseus cluster (Romanishin ApJ 301, 675; cf. als Silk + ApJ 307, 415). Thermal instabilities in cooling flows are the cause for the optical emission filaments in and around a number of galaxies (Fabian + ApJ 305, 9). A radio tail may be identified with an X-ray source (Burns + ApJ 291, 611). From high-excitation Fe lines in the X-ray gas an abundance of 0.4-0.5 times the solar value is derived (Rothenpflug + AA 144, 431; Singh + ApJ Lett 308, L51); this seems high if the acreting gas is assumed to be primordial. Theoretical models of cluster evolution has been presented by several authors (e.g. Peebles, Clusters and Groups p.405; Bhavsar + ibid.p.415; Salpeter Ann NY Acad Sci 422, 95; Yabushita + MN 213, 117; Allen + MN 216, 155; Cavaliere + ApJ 305, 651; Kaiser + MN 222,323).

Superclustering has been reviewed by Oort (Clusters and Groups p.1; Large-Scale Structure of the Universe p.209). He has proposed to detect super-pancakes by matching absorbtion lines in neighboring QSOs (AA 139, 211). Very large-scale structure is revealed in the redshift distribution of galaxies at $B \sim 22^m$(Koo + IAU Symp 124, 383). No clear filamentary structure has been found in a deep galaxy sample (MacGillivray + J Astr Ap 7, 293; see also Fry ApJ 306, 366). But filamentary structure around the Coma cluster was pointed out by Fontanelli (AA 138, 85). "Bubble" structures of diameters of 5000km.s^{-1} in a volume containing the Coma cluster are detected in the extended CfA redshift survey (Geller + IAU Symp 124, 301). Haynes + (ApJ Lett 306, L59) find a connection between the Pisces-Perseus supercluster and the Virgo complex (cf. also Haynes + Galaxy Distances p.117). The Hercules and Perseus superclusters were studied by Moles + (MN 213, 365). Superclusters in Zwicky's classical sence, i.e. clustering of clusters, were searched for and detected in the distribution of Abell clusters by Bahcall + (ApJ 270, 20; also Burns IAU Symp 124, 319). The superclusters are elongated in the redshift direction, possibly indicating large-scale deviations from a quiet Hubble flow (Bahcall + ApJ 311, 15; Bahcall IAU Symp 124, 335).

The infall velocity of the LG towards the Virgo cluster was determined to be 220±50 km s^{-1} (Tammann + ASpj 294, 81); more recent determinations have found similar values (de Freitas Pacheco AJ 90, 107; Kraan-Korteweg, The Virgo Cluster p.397; Visvanathan, Galaxy Distances p.99). A more complex flow pattern has been suggested by de Vaucouleurs + (ApJ 297, 27). A quadrupole moment of the velocity field in the Virgo complex could be due to the "great attractor" in the Hydra-Centaurus direction (Lilje + ApJ 307, 96); this apex direction was originally proposed to explain the MWB dipole (Shaya ApJ 280, 470; Sandage + Large-Scale Structure of the Universe p.127). A corresponding dipole moment has been suggested for the distribution of IRAS galaxies (Meiksin + AJ 91, 191; Yahil + ApJ Lett 301, Distances of nearly 400 ellipticals indicate a large-scale flow towards an apex at 4500 km s^{-1} in the direction of the Centaurus cluster with a peculiar motion of the Sun of ~570 km s^{-1}; the superimposed random velocities are <245 km s^{-1}; the flow, however, if combined with our Virgocentric infall velocity does not explain the MWB dipole (Lynden-Bell ApJ in press), particularly for the last two paragraphs see also the Report of Commision 47.

5. Quasars and Related Topics
(S. D'Odorico)

It is not possible in this limited space to discuss all of the many interesting results which have appeared in this widely defined subject. The aim of this report is just to provide to a newcomer to the field a reasoned list of the most important contributions in the various subtopics. For a complete view see also the progress reports on galaxies, radiostrouomy and cosmology in this volume.

I. CONFERENCES, WORKSHOPS AND CATALOGUES

Three IAU Symposia were closely related to QSOs: IAU No. 119 "Quasars", IAU No. 124 "Observational cosmology" and IAU No. 130 "Evolution of Large Scale Structure in the Universe". Proceedings of other meetings on the subject include the 24th Liege Meeting "QSOs and Gravitational Lenses", the workshop in Manchester "Active galactic nuclei", the 7th Santa Cruz Workshop "Astrophysics of active galaxies and QSOs", the Tata Institute school on "Extragalactic energetic sources", the NRAO workshop "Physics of energy transport in extragalactic radio sources",the Trieste Meeting "Structure and evolution of active galactic nuclei" and the NOAO workshop "Continuum emission in active galactic nuclei". No references to articles published in the Proceedings of these conferences are made in this report. Three new editions of QSO catalogues have appeared in 1987: in ApJ Suppl. Ser. 62, 751; as ESO SR No. 5 and as an Asiago-Padova Observatory Contribution. Other related catalogues are those of Markarian galaxies (ApJ Suppl. Ser. 62, 751) and of BL Lac objects (AJ 93, 1).

II. SURVEYS AND SYSTEMATIC INVESTIGATIONS

In the last three years the sample of QSOs available for statistical studies has significantly expanded with the results of several new surveys in selected areas of the sky being published. Both color and grism -based techniques have been employed (ApJ 283, 50; ApJ 287, L3; MN 213, 485; ApJ Suppl 57, 523; AJ 89, 1658; AJ 90, 987; Nature 314, 238; ApJ 295, 94; MN 216, 589 and 623; MN 218, 445; MN 220, 1; AA Suppl 63, 1; PASP 98, 285; ApJ 310, 518; MN 223, 87; AA Suppl 67, 551; AJ 92, 203; ApJ 314, 129; ApJ 316, L1).

The new results have been used to discuss the problems of the density and luminosity distribution of QSOs at different epochs and that of their evolution. These topics have been also addressed in ApJ 298, 448; ApJ 299, 109 and 799; MN 213, 389; AA 170, 37; PASP 38, 611; ApJ 300, 224; ApJ 311, 156; ApJ 312, 589; AA Suppl 67, 267; Nature 325, 131; MN 227, 717 and ApJ 316, L5.

It is worth noting that the discovery of several QSOs with $z > 4$ has been reported while this review was being written. This suggests that the techniques which have been employed so far have not been very effective in the detection of objects at high redshifts. We can now expect further progress in this area, and it remains to be seen whether the generally accepted notion of a decrease of QSO in number density at large z will eventually be confirmed.

The QSO data base has also benefitted from other systematic investigations (Act. Ast. 34, 117; MN 211, 105; ApJ 285, 584; AA Suppl 61, 191 and 225).

The research mentioned above has been carried out mostly at optical and radio wavelengths, but important results on QSOs have been also obtained in the X-ray band (ApJ 284, 491; AJ 89, 1658; ApJ 292, 357; J AA 6, 49; MN 220, 51; Bologna X-Ray Astr.'84, 419 and 463; ApJ 297, 177; ApJ 299, 814; ApJ 303, 614; ApJ 308, 53; ApJ 310, 291; ApJ 314, 111; ApJ 318, 188) and in the infrared (MN 212, 631; ApJ 308, 815 and L1; ApJ 309, L69).

III. QSOs NEAR GALAXIES AND GALAXIES NEAR QSOs

Special QSO surveys have been conducted in the vicinity of bright galaxies and in clusters either to prove an association (with success, according to the authors of some of these investigations) or simply to obtain background sources to be used to study the interstellar and intergalactic medium (MN 226, 58; AJ 89, 958; MN 210, 373; AA 138, 408; ApJ 283, 59; MN 211, 443; ApJ 285, 44; Chin AA 8, 238; ApJ 285, 355; AA 151, 264; ApJ 288, 82; ApJ 288, 201 PASP 97, 1149; MN 221,897; MN 222, 787; ApJ 319, 687 and 693).

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The opposite approach, that is to search for faint galaxies near QSOs, has tempted more observers. Many studies have dealt with the possible presence of QSO "host" galaxies, and many detections have been reported (AA 138, 337; ApJ Suppl 55, 533; ApJ 283, 64; ApJ 287, 555; ApJ 293, 120; ApJ 295, L27; MN 214, 241; ApJ 291, L37; AJ 90, 1642; ApJ 298, 275; ApJ 306, 64; ApJ 311, L1; ApJ 312, 518; ApJ 316, 584; ApJ Suppl 62, 681; AJ 93, 255). Most of these studies have been confined to objects at $z < 1$ and have found that different galaxies can host a QSO, the morphological type being possibly correlated with the radio properties of the QSO.

To the study of faint galaxies in the direction of QSOs belong also deep photometry of galaxies in QSO fields (PASP 97, 684; MN 223, 173; ApJ 319, 28; ApJ 62,681 and ApJ 139, L39) and the successfull searches for galaxies close to the line of sight to the QSO and at the redshift of metal absorption systems seen in the spectrum of the QSO (AA 155, L8; MN 210, 873; MN 223, 173; AA 161, 206; AA 175, L1; AA 180, 1 and ApJ 319, 683).

IV. CLUSTERING

A number of authors have addressed the question of clustering of QSOs at various scales and at various epochs, starting from the results of a survey or from a statistical analysis of existing data. Weak or no clustering was generally found, but with larger,more complete samples becoming available, the case for strong clustering at high redshifts is building up (AA 136, 69; MN 214, 905; MN 218, 139 and 587; ApJ 311, 578; MN 227, 1; MN2 27, 739; MN 227, 921; Nature 326, 773). Discussions on QSO pairs in particular can be found in AA 143, 451; Nature 317, 413 and Nature 323, 185 and 186.

V. THE EMISSION SPECTRUM

The emission lines in the spectrum have been used to investigate the physical conditions and the composition of the matter near to the cores of QSOs. Note that the studies of Seyfert and other active galaxies, not referenced here in detail, are strictly related to this topic as these objects are likely to represent QSOs of low luminosity at small redshifts. QSO spectra, their modelling and interpretation, are treated in NASA CP-2349, 133; ApJ 283, 70; ApJ 284, 497; ApJ 288, 94; ApJ 290, 394; ApJ 291, 128; PASP 97, 966; MN 218, 331;AJ 91, 226; ApJ 295, 394; AA 145, 324; ApJ 298, 114; AA 156, 121; MN 225, 55; ApJ 302, 56; ApJ 308, 805; MN 226, 629; ApJ 310, 40 and ApJ 314, 145.

VI. THE BROAD ABSORPTION LINE QSOs (BALs)

A proportion of QSOs possibly as high as 10% show broad absorption lines in their spectra indicative of an outflow of matter at velocities which can reach a significant fraction of the velocity of light. Detailed studies on these lines share light on the mechanism and energetics of the central power source while studies on the frequency of these objects versus "normal" QSOs have been used to try to understand which evolutionary stage they represent or under which conditions they develop, both questions being far from being fully resolved (ApJ 282, 33; MN 211, 813; ApJ 294, L1 and L73; ApJ 296, 416; ApJ 302, 64; ESA SP-263, 627; AA 177, 42; ApJ 310, L1; ApJ 317, 450 and 460).

VII. ENERGY DISTRIBUTION ANS MODELS OF THE CENTRAL POWER SOURCE

Studies on the overall energy distribution in the continuum and on the central engine have been presented in AJ 89, 1275; JAA 5, 495; MN 213, 97; MN 216, 63; AJ 90, 405; ApJ 288, 32; ApJ 289, 451; AJ 90, 998; ApJ 296, 423; AZh 62, 662; ApJ 300, 216; MN 224, 257; MN 226, 601; ESA-SP 263, 601; ApJ 313, 164 and 171.

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III. GRAVITATIONAL LENSES

More than 60 papers have been published on gravitational lenses in the last three years, testifying the amount of work which went into this subject which is 8 years old only. Apart from the interest of studying in the real world an effect predicted by the theory of gravity, GL are potential sources of information on the lensing objects themselves, galaxies or clusters at high redshifts, provide a confirmation of the cosmological distance of QSOs and may affect the statistics of QSO counts. Reports on the actual discoveries, new data and discussions of individual cases can be found in ApJ 282, L1; MN 210, L1; AA 138, L19; ApJ 283, 512; AJ 90, 691; Nature 316, 102; AJ 90, 1399; ApJ 294, 66; AA 149, L13; ApJ 300, 209; AA 158, L5; Nature 321, 139; ApJ 303, 605; AA 166, 119; ApJ 312, 45; Nature 3 16, 268 and Nature 329, 696.

The rise and fall of the GL identification 1146+111 A,B (most likely a close QSO pair) is told in as much as 10 published papers (see eg Nature 321, 142 and 569; Nature 323, 784; ApJ 313, 28) and provides instructive reading for anyone dealing with the interpretation of observational data.

Theory of GL for different lensing objects and different configurations is discussed in Nature 310, 112; ApJ 287, 26; 4th Grossman Meeting p1549; ApJ 310, 568; ApJ 312, 22; MN 224, 283; ApJ Suppl 68, 223; ApJ 313, 13; AA 174, 361; ApJ 315, 283; ApJ 317, 11; ApJ 319, 9. The effect of GL on the luminosity function and in general on the density of QSOs is treated in MN 215, 639; ApJ 300, 68; AA 179, 71 and 80; ApJ 316, L7; ApJ 318, L1.

IX. QSOs AS PROBES OF MATTER AT HIGH REDSHIFTS

With more large optical telescopes and efficient high dispersion spectro graphs now in operation, it has become possible to observe a relatively large number of QSOs at high dispersion, and then to study in detail through the absorption lines in the spectrum the distribution and the metal content of intervening matter at high redshifts. This technique has been very efficient and we may expect that it will be one of the main areas of application for telescopes of 8m in diameter or larger now under construction. We can distinguish between studies centered on absorption lines originating in HI clouds at redshifts smaller than the emission redshift of the QSOs (the so-called Lalfa forest) and studies centered on the metal lines of low and high ionization. In the first category fall the papers in AA 144, L17; ApJ 292, 58; MN 218, 25P; Astrofiz. 24, 321; MN 220, 1; ApJ 309, 19; ApJ 310, 583; MN 224, 13; ESA-SP 263, 435; ApJ 311, 610; AJ 92, 247; MN 224, 675; PASP 98, 1140; MN 224, 13P; MN 225, 1P; ApJ 316, L59; ApJ 319, 14 and 709.

To the metals systems, their ionization state, abundances and nature are dedicated the following references: AA 145, 59; ApJ 292, 362; ApJ 293, 387; ApJ 301, 116; MN 220, 429; AA 168, 6; AA 169, 1; ApJ 303, L27; ApJ 307, 504; ApJ 310, 40; ApJ 311, 610; ApJ 312, 50; ApJ 315, L5; ApJ 320, L75. For metal systems where the intervening galaxy has been identified, see also the work referred to in Chap. III.

X. 3C 273

We do not discuss in this report studies of single QSOs except for 3C 273. The first QSO to be discovered still attracts considerable attention because it allows very detailed studies due to its high brightness and to the small distance. For example the jet structure, which is related to the central power source, can be investigated in 3C 273 in much more detail than in any other object (Nature 314, 425; MN 216, 679; Nature 318, 343; AA 154,15; JAA 7,225; ApJ 289, 109; ApJ 313, 136). Studies at different wavelengths have been reported in AA 136, 351 and AA 182, L1 (X-rays), ApJ 283, 329, PASP 97,118, PASP 97,395, Nature 316,524, AJ 90, 2474, AJ 92, 1030 (UV and optical) and ApJ 298, 114 (radio). The overall spectrum is discussed in AA 140, 341 and Nature 323, 134. Models of 3C 273 are presented in AA 139, 289 (as the effect of a GL), in ApJ 285, 64 (as the effect of a continuous beam) and in ApJ 298, 114 (to explain radio outbursts).

XI. QSOs AS STANDARD CANDLES

Accurate optical and radio positions of a QSO have been obtained as a step to establish an extragalactic reference frame (AJ 93, 261). A study on aberration in QSOs has confirmed the constancy of c on a scale comparable to the size of the universe (ApJ 295, 24).

6. Galaxy Redshifts
(J.P. Huchra)

Surveys of galaxy cluster redshifts have been spurred onwards by the growth of interest in the large scale structure of the universe. In the last few years it has become increasingly obvious that the topology of large scale structures places crucial constraints of theories of galaxy formation, cluster formation and our basic cosmological models.

At the time of this writing, the number of galaxies with measured redshifts is approaching 25,000. 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 authors or from the Natinal Space Science Data Center in the U.S. or the Strasbourg Astronomical Data Center in Europe. Figure 1 is a plot of the surface distribution of galaxies with redshift in J. Huchra's ZCAT as of June, 1987. The Nearby Galaxy and Catalog of 2367 galaxies with redshifts less than 3000 km s^{-1} has been published by R.B. Tully and R. Fisher.

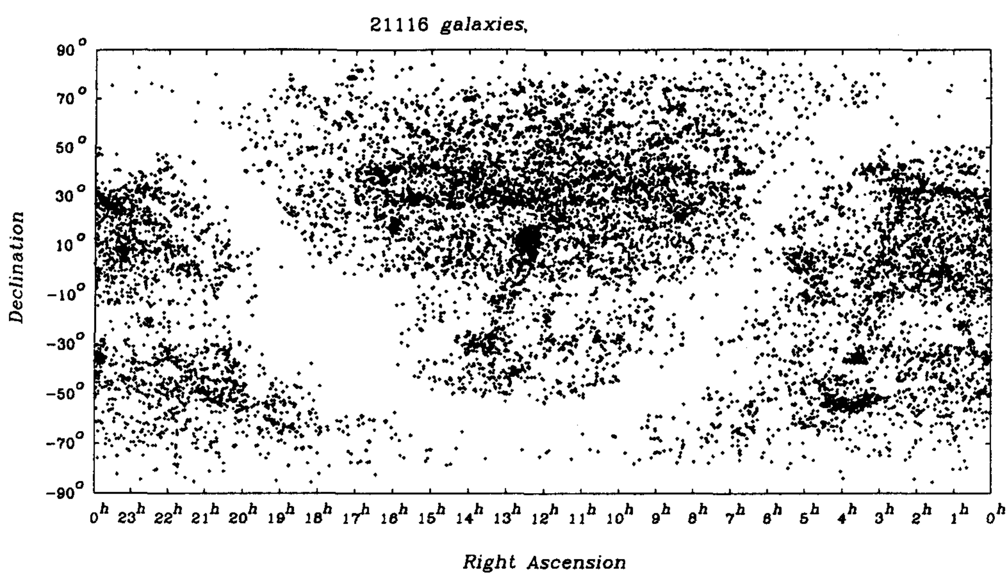

Figure 1. The Surface Distribution of Galaxies in ZCAT as of June 1987.

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Similarly, the number of galaxy clusters from the lists of Abell, Zwicky, Corwin, Ortwin and Abell and deeper surveys (eg. Gunn and Oke, and Sandage et al.) with measured redshift is nearing 1000. Catalogs of cluster redshift 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.

As digital detectors have become commonplace on small telescopes and as radio receivers became more sensitive, the number of galaxy redshift surveys has increased. Major large area surveys of optically selected galaxies (from the catalogs of Zwicky et al., Vorontsov-Velaminov, Nilson, and Lauberts et al.) are being carried out by Giovanelli and Haynes at Arecibo, by Huchra and Keller at Mt. Hopkins, by da Costa et al. in Brazil, by Davis, Tonry and Sargent at Las Campanas and by Fairal and Menzies and Davies in South Africa. Deeper redshifts surveys, usually over small areas where galaxies are selected by scanning photographic plates, are being done by Kirshner, Oemler, Schechter and Shectman at Las Campanas and McGraw Hill (the Bootes Void Survey), 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. Particular succes has been obtained at the AAT with a multiple object fiber-coupled spectrograph. These redshift surveys have confirmed the complexity of the galaxy distribution that was hinted at in earlier surveys and uncovered large voids, superclusters, and shell-like structures.

Studies of the internal dynamics of nearby galaxy clusters have also benefited greatly from the proliferation of advanced detectors and multiple object spectrographs. A decade ago, the number of galaxy clusters with more than 20 measured redshifts was only of order a dozen. The number now is nearly 100. Major contributions have come from the work of Melnick and Quintana, Dressler, Geller and Huchra and collaborators, Richter and and Huchtmeier and collaborators, Salpeter and Hoffmann (primarily the Virgo cluster), and from other groups using EFOSC and OPTOPUS at ESO, the fiber-fed spectrograph at the AAT, and the multislit spectrograph at the CFHT. Coupled with X-ray observations from the Einstein satellite, the emerging picture is that clusters are now in a variety of states with many far from dynamical relaxation.

Two major surveys of Abell cluster redshifts are now underway, prompted by the initial analyses of a 100 cluster sample by Bahcall and Soniera. These are the surveys of Karachentsev, Klypin and Kopylov using the SAO 6-m, and of Huchra, Henry, Postman and Geller using the MMT and CFHT. Although the results are only preliminary (because the Abell cluster catalog suffers from a variety of difficult selection effects) these surveys are confirming the large amplitude of the cluster-cluster correlation function found earlier. That degree of clustering had not been matched by any of the extant theories of large scale structure.

Observations of objects at large redshifts continued to be pioneered by Spinrad, Djorgovski and collaborators who have discovered several galaxies with strong Lyα emission at redshifts in excess of 1. Also noteworthy are observations by A. Wolfe and collaborators of high redshift damped Lyα absorbers that may be galactic disks.

In addition to optically selected galaxies, the survey done with the Infrared Astronomy Satellite (Neugebauer et al.) has provided extragalactic astronomers with tens of thousands of high latitude sources. Not only is that catalog a new finding list of active nuclei, but it is also a nearly whole sky and uniform survey of star forming galaxies. Radial velocity and spectroscopic identification work has been done by de Grijp, Miley, Lub and de Jong, by Lawrence et al., and by Kleinmann et al., and a large survey of all 2600 objects brighter than 1.95 Jy at 60 μm and further than 10° from the galactic plane has just been completed by Davis, Huchra, Strauss, Tonry and Yahil. This last survey is being used to compare the anisotropy of the galaxy distribution with our observed motion w.r.t the μ-wave background to derive the value of Ω.

Since the last report, progress on the derivation of a more accurate value for the Hubble constant through improvements in primary and secondary calibrators (eg. the Infrared Cepheid observations of McAlary, Madore, Freedman and others) has been offset both by the discovery of large scale flows within 6000 km s^{-1} by Burnstein, Davies, Dressler, Faber, Lynden-Bell, Terlevitch and Wegner and by the untimely death of Marc Aaronson, a good friend and a leader in distance scale research.

I would like to close by stressing to all astronomers the need to publish heliocentric velocities (cz) or redshifts (as $z = \Delta\lambda/\lambda$ in the optical convention), and also accurate 1950 positions for the galaxies they observe.

7. Extragalactic Research in the U.S.S.R.

(E.Ye. Khachikian)

Abreviations:

Kaz	- Trudy Kazan Astron Obs.	Ye U	- Yerevan State University
Af	- Asrofizika, Erevan	Crim	- Izvestia Crimean Astrophys. Obs.
AZ	- Astron. Zhurnal	LGU	- Trudy Astron. Obs. Leningrad Univ.
LAZ	- Letters to AZ (Pis'ma)	SAO	- Communic. Special Astrophys. Obs.
AZ	- Astron. Circ.	BAO	- Communic. Byurakan Astrophys. Obs.
Tartu	- Publ. Tartu Obs.	SAO Iz	- Izvestia Special Astrophys. Obs.
SA	- Superassociation		

I. SURVEYS AND LISTS OF GALAXIES

Markarian + (Af 20, 513; 23, 439; 25, 345) continue the second Buyrakan Spectral Survey (SBS); The number of UV excess objects reaches 500. Stepanian + (SAO, 50, 21) described the method of observations and selection of SBS's objects. The history and perspectives of the first Byukarian Survey are discussed by Lipovetsky (SAO 50, 12). Afanas'ev + described the deep spectral survey (up to 23m) on the 6-meter telescope using the slitness spectroscopy method (SAO 50, 31). Poljakova obtained objective prism spectra of about 100 galaxies with dispersion 660 A/mm by Hγ (AC No. 1368). Markarian + (Af 26, 15) showed that FBS and SBS more effectively select QSO than other surveys. Khachikian made a survey of UV-galaxies (Highlights of Astronomy, 6, 459), Markarian galaxies and star formation regions (IAU Colloquium No. 78; SAO 50, 39) and studied morphology and spectro-photometry of the central regions of Markarian galaxies (IAU Symposium No. 121). I. Pronik made a survey of variability in the spectrum of the nuclei of 37 Seyfert galaxies (IAU Symposium No. 121). It is shown that the spectra are changing on a time scale from hours to days. Kazarian and Khachikian made a survey of morphology, spectroscopy and forms of activity of UV-galaxies (Ye U, Publication, Physics 5, 149; Problems of theory of superdence bodies, Ye U press, p.195, 1984). 15 new dwarf galaxies in the IC 342 complex of galaxies was found by Borngen and Karachentseva (Astron. Nachr 306, 301). A catalogue of 1051 isolated galaxies with $m < 15.7$ was published by Karachentseva + (Bull. inf. Cent Donnees stellairie No. 30, 125).

II. ACTIVE GALACTIC NUCLEI

Spectral observations of galaxies with UV excess from Bukarian surveys was continued by Markarian + (Af 21, 35; 21, 419; 22, 215), Denisyuk + (Af 20, 525; SAO 50, 88). Spectral and optical variability of active galactic nuclei is observed and discussed by Merkulova + (Crim 68, 85; 71, 160), Pronik (Crim 68, 75; SAO 50, 64), Lipovetsky + (Af 24,437), Chuvaev (SAO 50, 73; LAZ 11,803), Merkulova (Crim 75, 175), Neizvestnij (SAO 50, 74), Ljutij + (LAZ 10, 803), Bocharev (LAZ 10, 239), Shevchenko (LAZ 10, 896; 11, 83; 11, 432), Gorbatskij (Af 22, 267), Ljutij + (LAZ, 12, 187), Doroshenko + (Crim 73, 143; AA 163, 321). Spectrophotometric investigation of active galaxies is carried out by Lipovetskij + (Af 21, 5; 24, 437; SAO 50, 43), Andreassian and Khachikian (Af 24, 17), Burenkov (Af 24, 349), Kazarian + (Af 22, 431), Amirkhanian + (Af 22, 239). UBV photometry of galaxies with UV excess has been made by Tamax zian (Af 20, 43), Kazarian + (LAZ 10, 815); B,V photometry by Kostjuk + (SAO 20, 68); Hα-electrophotometry by Asadulaev + (AC No. 1415)). Polarimetric and electrophotometric study of BL LAC and BL Lac type objects are carried out by Gagen-Torn + (AZ 61, 925;Af 22, 5; 25, 485) and Marchenko (Af 22, 15). Surface brighness distribution in Seyfert galaxies is studied by Afanas′ev + (Af 24, 333; 24, 425; 25, 5; SAO 50, 60) and Metik + (Af 23, 451) for NGC 1275. Dependence between luminosities of Seyfert galaxies and their active nuclei is mentioned by Dibaj + (AZ 62, 468). A method of determination of luminosity function was proposed and applied to Seyfert galaxies by Arakelian (Ap J 301, 92). The luminosity function of a sample of 219 Seyfert galaxies is determined by Reshetnikov (Af 24, 33); for faint galaxies with UV continuum by Stepanian (Af 21, 445) and Terebizh (SAO 50, 34). Gas dynamics in active galactic nuclei in terms of emission line properties is discussed by Pronik (Crim 72, 135; SAO 50, 64), Mikhailov (SAO 50, 84), Bochkarev (SAO 50, 77), Vilkoviskij (SAO 50, 100), Shevchenko (LAZ 11, 181). Models of active galactic nuclei are discused by Schklovskij (AZ 61, 833), Ljutij, Cherepaschuk (AZ 63, 897), Romanova (SAO 50, 80), Dibaj (AZ 61, 417), Silchenco + (A Sp Sci 117, 293), Afanas'ev (SAO 50, 57), Suchkov (SAO 50, 91). Some theoretical aspects of galactic nuclei are discussed by Zentsova (AZ 62, 1227), Galev (LAZ 11, 181), Lavrushkina (Acad USSR, 48, 2080). Burenkov and Khachikian measured the velocity field of UV-galaxies with starbirth regions Mark 7 (Af 19, 619) and Mark 297 (IAU Symposium No 121). Petrosian completed the statistical investigation of SA in UV-galaxies (Af 21, 57). Andreassian and Khachikian (Af 22, 441) carried out spectrophotometrical investigation of SA in NGC 2820 A. Detailed spectrophotometry with 6 m telescope and long slit have carried out by Burenkov + for Mark 111 (Af 21, 433), by Khachikian + for Mark 306 (Af 24, 5), by Burenkov and Khachikian for Mark 3353 (Af 24, 349), by Andreassian + for Mark 71 (Af 25, 507), Petrosian + discovered four UV-galaxies with jets (Af 22, 229). Kalinkov + applied numerical methods of the photometry of Markarian galaxies (Af 26, 29). Joeveer found a deficiency of normal elliptical galaxies among Markarian galaxies (Af 24, 25). Yegiazarian carried out detailed spectral observations of 12 UV-galaxies from Kazarian lists. The redshifts and some physical properties are measured. No 199 shows Sy characteristics (Af 25, 425; BAO 57, 8; 58, 68).

III. QUASARS AND COMPACT GALAXIES

Markarian + (AC No 1346, 1381; 1384, LAZ 13, 3) observed new QSO from his lists of UV excess galxies. Levshakov + (SAO 50, 48) studied three quasars from SBS with 6 m telescope. Varshalovich + (Adv space Res 3, 187) studies absorption-line spectra of quasars Levshakov and Varshalovich (MN 212, 517) found molecular hydrogen in z=2.811 absorbing material towards the quasar PKS 0528-250. Properties of optical variability of quasars and correlation of optical and radio activity of 3C 345 is studied by Babadjanyanz + (Af 21, 217; 22, 247; 23, 459; AZ 62, 627). A method of the separation of radiation components of variable extragalactic sources was proposed by Gagen-Torn (Af 22, 449). Photographic photometry of compact extragalactic objects was continued by Skulova (LGU 39, 43). Classification method of compact galxies is discussed by Byorngen and Kalloghlian (Astr Nachr 306, 81). Multiple light scattering as a possible cause of visual polarization is discussed by Loskutov + (Af 23, 307). Some indications of the symmetry of emitting regions of quasars with broad absorption lines are discussed by Grinin (LAZ 10, 643). The possible contribution of dwarf galaxies and globular clusters to Lyα and 21 cm lines in the spectrum of distant QSO′s is discussed by Komberg (Af 24, 321). Properties of hot gas in the nuclei of quasars is discussed by Zentsova (AC No 1417).

Lebedev and Lebedeva (SAO Izv 19, 16) found no significant periodicity in the space distribution of quasars in a search for "antipodal" images of quasars (SAO Izv 19, 12). Komberg (Af 20, 351) discussed double quasi-stellar object Q 0957-561 A, B as a possible pair of galaxies.

IV. STRUCTURE AND KINEMATICS OF GALAXIES

New stellar associations in M31 were reported by Efremov + (IAU Symposium 116). The resolution of blue star-like objects in Arp's ring around M81 was made by Efremov + (LAZ 12, 434). Ten candidates per luminous red supergiants were found in M31 by Efremov + (A Sp Sci, 129, 39). Investigation of colour-luminosity diagrams of 12 globular clusters in the SMC & 22 in the LMC showed that star formation histories are different in LMC and SMC (Frantzman, LAZ 12, 281). A singular pronounced anisotropy in the apparent major axis orientations of Uppsala and ESO/Uppsala catalogue gälxies was shown by Mandzhos + (LAZ 11, 495). From a study of the cross-section of a spiral arm of Andromeda galaxy Efremov showed, that the structure of S4 arm between OB 75 and OB 82 agrees with the density wave theory (LAZ 11, 169). Photoelectric photometry of globular clusters in Andromeda nebulae was made by Sharov + (LAZ 10, 583; AZ 61, 245). BV photometry and spectroscopy of "Garland"- an unusual object near NGC 3077- was made by Karachentsev + MN, 217, 731). The integrated colours of some very red spiral galaxies is discussed by Silchenko (A Sp Sci, 117, 83). Optical variability of the nucleus of M33 was discovered by Ljutii + (LAZ 12, 187). Photometry of nuclear region of NGC 1569 was made by Merkulova + (Kaz, 50, 83). A catalogue of rotation curves of normal galaxies was compilled by Kyazumov (AZ 61, 846). Rotation curves were studied and masses of galaxies were estimated by Mineva (LAZ 11, 811). The direction of rotation of spirals in 109 galaxies was studied by Pascha (LAZ 11, 3). Estimates of masses of disks and haloes of galaxies on the basis of local stability criterion for a disk was made by Zasov (LAZ 11, 730).

Photometric colour profiles of spiral arms of galaxies was dicussed by in Traat (Tartu 51, 181). Effects of galaxy inclination in surface photometry are discussed by Kaazik (Taru, 98, 100), and the problem of hidden mass in galaxies by Gurzadian (AZ 63, 812). Gas/dust ratio in M33 is determined by Sharov (LAZ 11, 313). Halo/disk mass ratio's were discussed by Zasov (LAZ 11, 307). The magnetic field distribution in spiral galaxies was investigated by Ruzmaikin + (AA 148, 335). Problem determination of masses of elliptical galaxies and their X-ray radiation was discussed by Krol (Af 23, 227). Gas dynamics in galaxies is studied by Volkov (Af 24,57; 24, 477) and Sotnikova (Af 25, 139). Ionization equilibrium condition was dicussed by Sidorov (Af 21, 353). Some aspects of galaxy modelling was discussed by Silchenko (AZ 61.634), (SAO 50, 91). Kalloghlian and Kandalian showed that radio emission of SB galaxies more often is connected with the central regions of galaxies (Af 24,47). Malumian (Af 22, 25) discussed the question of colours and Byurakan classification of nuclei of galaxies.

V. SYSTEMS OF GALAXIES.

Burenkov + described four pairs of galaxies one of which is a UV galaxy (LAZ 10, 403). Vennik (A.N. 307, 157) determined the visual parameters of groups of galaxies. Mahtessian studied the connection of some physical parameters of galaxies with density and morphological type (BAO 17, 13, 21) of the groups in which they are located. Shakhbazian and Shapovalova (Af 20, 179) studied morphlogical structure of two compact groups of compact galaxies. Plaksina (Probl. Cosm. Physics, Kiev 19, 118) studied the orientation of double galaxies on the sky. Djomin + (AZ 61, 625) studied CI of galaxies in double systems and confirmed the Holmberg effect. Bisnovatii-Kogan (Af 21, 87) derived the kinematical characteristics of pairs of galaxies. Karachentsev considered the relation of surface brightness of isolated and double galaxies with some of their parameters (SAO Izv 19,3). Konukov has shown that the distribution of the galaxy component of a cluster can be determined from a boundary problem for the gravitational potential of a self-consistent field (Af 22, 273). Vinokurov + discussed the probable mechanism of formation of breaks in the luminosity function of galaxy clusters (AC No.1390,5). Arkhipova + (AZ 64, 233; 63, 16; AC No. 1329,1) studied the kinematics of gas in close pairs, chains and groups of galaxies. Their M/L ratio is small and testifies to their stability. Stephanian (Af 21, 445) discovered 35 emission galaxies in A634. Egikian + made two colour photometry of about 420 galaxis in the clusters A 1213 (Af 21, 21) and A 426 (Af 23, 5). Petrossian and Turatto considered the relation of Markarian galaxies with Zwicky clusters (AA 163, 26) and determined redshifts of 12 of them (Af 24, 205). Petrossian has shown that physical characteristics of Sy do not depend on the multiplicity of the system of which they are members (BAO 57, 3). Some aspects of dynamical evolution of triple systems was discussed by Anosova + (LGU 40, 66), by Anosova (A Sp Sci 124, 217. Gorbatsky (Af 20, 61) discussed a possible mechanism of heating in intergalactic gas in clusters. Gas equiluilibrium conditions in gravitational fields of massive galaxies in clusters was discussed by Volkov (Af 62, 450).

Spectral observations of low surface brightness galaxies in M81 group region was made by Karachentsev + (Af 21, 641). Vennik and Kaazik listed new redshift for 31 galaxies, selected in the vicinity of nearby groups of galaxies (Af 23, 213). Kopylov + presented the redshift measurements of rich clusters of galaxies (AC No. 1393). Karachentsev + measured individual masses of galaxies in pairs (AZ 62, 417; LAZ 10, 563); Malykh and Orlov proposed a method for the statistical study of multiple system configuration to judge their dynamic properties (Af 24, 445). Barausov and Chernin showed that interaction of shock waves with interstellar medium gives a good chance for formation of the group of spirals (LAZ 11, 883). Aliakbarov + (SAO 8, 81) found no evidence for the Sunyaev-Zeldovich effect in X-ray clusters of galaxies.

VI. LARGE SCALE STRUCTURE OF THE UNIVERSE

Fesenko has shown that the irregular extinction provides the observed dependence of covariance function on distance (Af 24, 453), and that there are no evidences for the existence of the local supercluster from the distribution of radial velocities and angular diameters of galaxies (Af 25, 161). Stepanian (LAZ 11, 575) using the space distribution of SBS emission galaxies found a large scale structure with D=50 Mpc. Shandarin and Klipin (AZ 61, 837), in the frame of adiabatic theory have shown that rich galaxy clusters are formed as a result of long-scale schemes inside of a supercluster. Gilfanov and Syunjaev have shown that the diffusion of elements in intergalactic gas can increase the abundance of Deuterium, Helium and Lithium in the central parts of rich clusters (LAZ 10, 329). Sotnikova considered the evolution of interstellar clouds initially out of pressure balance with external hot intergalactic gas (Af 25, 139). The prediction of the global rotation of the universe is discussed and the problems of cosmic magnetic fields and energy problem in active galaxies are considered by Muradian (IAU Symposium No 121). Ozernoy + (LAZ 12, 325) found arguments for an explosional origin of cosmic void in boots. Tago + (MN 218, 177) discussed a prominent 50 Mpc long string of galaxies in Bootes. Einasto + (MN 219, 457) continued his investigation of structure of superclusters and formation. Agekyan and Yakimov proposed a method for determining the presence of structure in a field of objects and for estimates of the parameters of a structure if it exists (AZ 63, 214).

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

Some 200 papers on, or related to, the Magellanic Clouds (MC) are published each year. This level of activity reflects the crucial importance of MC for extragalactic and galactic distance scales; for many areas of stellar evolution, stellar

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structure and pulsation theory; as well as for the chemical evolution, structure, kinematics and interaction of galaxies. In the following, references are frequently omitted when they can be traced from papers cited.

I. DISTANCE, STRUCTURE, MAGELLANIC STREAM

Evidence on MC distances has been summarized (Galaxy Distances and Deviations from Universal Expansion (GD) Reidel 1986 p 7 and Feast, Walker An. Rev. AA in press). True moduli of 18.47 (LMC) and 18.78 (SMC) were derived, based primarily on Cepheids. Main sequence fitting to MC intermediate age clusters may yield slightly lower moduli (~18.2 for the LMC), but the effects of convective overshooting (wich remains contentious GD p 15) and other effects (see above references) may have led to these distances being underestimated. In more recent work, Mateo, Hodge (ApJ in press) find for the LMC intermediate age cluster LW 79, 18.4±0.2. Strömgren photometry of LMC B supergiants (MN 219, 495) gave 18.8±0.3 whilst spectral types of OB stars gave 18.3±0.3 (AJ 92, 48). A direct Baade-Wesselink analysis using BV photometry and Kraft-Parsons coefficients gives for 6 LMC Cepheids, 18.4 (internal error ~±0.1) (Imbert, Marseilles preprint 44). This is in accord with the result that MC Baade-Wesselink radii of Cepheids agree with the galactic period-radius relation (MN 220, 671).

The Gascoigne sequence on wich Grahams LMC RR magnitudes depend has been strengthened (PASP 98, 1162) whilst 10 RR Lyraes have been found in NGC 1786 (LMC) (PASP 97, 676). There is as yet no compelling evidence for different MC distances for objects of different ages. Nevertheless given the known great depth of the SMC such differences might well arise. Whilst there is general agreement that the SMC is very extended in the line of the sight, there is still considerable uncertainty as to its structure and kinematics. In particular the depth deduced from Cepheids agree with extensive phase coverage (MN 218, 223; 222, 449) is considerably less than infered from less extensively observed Cepheids (ApJ 301, 664). Welch et al. (ApJ in press) suggest that this is due to the greater uncertainties in the adopted distances of the latter. To obtain a clear picture of the kinematics it will probably be necessary to combine accurate Cepheid distances from multi-colour, multi-observational work with extensive radial velocities (E.G. Stobie and Hatzidimitriou, in progress). The structure may be quite complex since interstellar line velocities suggest the two 21 cm components, the lower velocity one is closest, whilst two of the most distant Cepheids in the sample with accurate distances belong to the low velocity component (cf above references). Also, ultraviolet work suggests additional high and low velocity components in front of the main body of the SMC (ApJ Suppl 59, 77, ApJ 292, 122).

There still remains some problem in assigning gas to the LMC or the halo of our galaxy (cf. the complex interstellar spectrum of SN 1987A Vidal-Madjar + AA in press) some components of which may be due to shells expanding from 30Dor (see also ApJ 310, 700). It has been suggested (ApJ 303, 1987) that the gaseous components of both MC are very extended in the line of sight and it remains to be seen whether this can be reconciled with the evidence (spatial, kinematic) that young LMC stars are confined to a plane. Further evidence for optical nebulosity, and for young stars, in the bridge between the MC has been obtained (Nature 316, 705; 318, 160; MN 223, 317). A new 21 cm study of the LMC (AA 137, 343) shows considerable non-circular motions superimposed on the differentially rotating disk. Extensive Coravel radial velocities of F-M stars in the MC (AA Suppl 62, 23; 67, 423) wil enable more detailed kinematic modelling. The Marseille group find that super-associations in the LMC have a very small velocity dispersion (5 km s^{-1}). A study of the radio continuum morphology of the MC (1.49 Hz) has been published (AA 159, 22). Amongst basic data produced are BVR data on 2600 MC foreground stars (AA Suppl 68, 63). Much still remains to be learned about the Magellanic Stream, a high sensitive radio survey shows the highly complex gas distribution in the stream (AJ 90, 1801). Spicker and Feitzinger (AA in press) have made a statistical turbulence analysis of the LMC, the first complete stellar system in wich this has been done. The largest eddies are 1-2 kpc in size. Feitzinger, Braunsfurth also attempt a quantitative analysis of the overall (spiral) structure of the LMC (AA 139, 104).

II. ABUNDANCES, CLUSTERS

A variety of arguments suggest metal deficiencies (Fe peak) for young objects in the LMC, SMC of 1.4 times and 4.0 times respectively and some recent work agrees with this general result (cf. AA 155, 72; 155, 145; AJ 89, 1705). Light elements (CNO) in HII regions appear more deficient than this (cf. ApJ 292, 155 and earlier papers). It would be very important to obtain more information on the abundances of different elements and their variation with stellar age. A particulary interesting result concerns the prototype young globular cluster NGC 330 (SMC). Various lines of evidence (AA 168, 197) (Spite +) ApJ 312, 195 and references there) suggest that stars in this cluster have [Fe/H] as low as -1.5. Some of the results depend on the [CNO/Fe] value (but not Spite +). Further work on this and other clusters is desirable since, taken at its face value, the result suggests that the origin of the young globular cluster stars is quite different from that of the young field (which have [Fe/H] ~ -0.6). A number of elements show a depletion factor of ~2 in the interstellar medium of the LMC compared to our galaxy (MN 217, 115). Low abundances are amongst the factors responsible for low CO emission in the MC (ApJ 303, 186). Old red giants in the SMC halo have [Fe/H] = -1.6 with a real spread, Δ[Fe/H] ~ 0.3 comparable to the abundance spread shown by globular clusters in the halo of our galaxy (AJ 91, 275).

A very large amount of work continues on clusters of all ages in the MC. Their relevance to distance scales is mentioned above. Other primary concerns are ages, metallicities and comparisons with evolutionary calculations. The clusters can be roughly classed in three groups; (1) Intermediate age (1-2 Gyr) with [Fe/H] ~ -0.5 (LMC) or -0.9 (SMC) (ApJ Suppl 60. 893; ApJ 305, 214; 297, 582; 304, 265; 284, 108; 283, 552; AJ 92, 1334; AA Suppl 67, 373; 64, 189; PASP 97, 753; Mateo, Hodge in press). NGC 1831 sometimes considered in this class is apparently younger (0.3 Gyr, PASP 96, 947); (2) some old globular clusters of age ~10 Gyr (ApJ 298, 544; 311, 113; Olszewski +, Steward Preprint 701) Kron 3 is 5-8 Gyr old (ApJ 286, 517); (3) Young clusters (e.g. ApJ 292, 130; 304, 617; Obs 104, 161; AA 134, L1; PASP 98, 1133). Clusters younger than ~8 Gyr have C stars at the tips of their giant branches, Younger than ~0.8 Gyr the giant branches are populated by the M stars (ApJ 288, 551). It has been argued that convective overshooting in intermediate mass stars affects very considerably the interpretation of the C-M diagrams of MC clusters (AA 150, 33 cf. also Brocato, Castellani, preprint). The age-metallicity and age-frequency distributions of MC clusters are important indicators of evolution in the MC and from them Elson, Fall (ApJ 299, 211) find no evidence for bursts or star formation though this is not the conclusion of other workers (AA 165, 84; 156, 261; see also ApJ 285, 595; and Wielen I.A.U. Symposium 126 in press). The luminosity function of LMC clusters is simular to that of open clusters in our galaxy (PASP 97, 692). A mass to light ratio of 0.42 is found for the old LMC cluster NGC 1835 (ApJ 288, 521). Contrary to earlier suggestions there now seems no correlation between LMC cluster ellipticities and age (ApJ 283, 598; AA 146, 293). Various parameters of MC clusters, are discussed by Kontizas and co-workers (AA 131, 58; 159, 305; AA Suppl 65, 207; 65, 283; 67, 147, 68, 357; 68, 493). 213 new clusters and a list of SMC associations were published (PASP 98, 1113; 97, 530).

III. HII REGIONS, PLANETARY NEBULAE, SNR, INTERSTELLAR MATTER

30 Dor is the prototype supergiant HII region and its stellar content, particularly its concentration of WR stars remains a challenge to theoretical models (ApJ 295, 109; 312, 612; AA 153, 235; MN 224, 435). The possibility that R136 contained a supermassive star was finally laid to rest by Weigert, Baier (AA 150, 218) who resolved R136a into a cluster of 8 objects (cf. also PASP 96, 999; ApJ 283,

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560). It has been concluded that R136a alone can energize the observed kinematics and structure of the 30 Dor Nebula (MN 211, 867 cf. also MN 211, 521; AA 153, 235). Kinematic studies of ionized shells in the MC place restrictions on models though as yet these features are not fully understood (AA 137, 512; 138, 57). The nature of LMC ring shaped nebula has been discussed (AA 160, 21). There is considerable interest in compact (high excitation, high density) HII regions in MC (AA 139, 330; 144, 98; 145, 170; 162, 180). These may represent a distinct class of HII region. Other compact HII regions are of low excitation (MN 209, 241). Molecular hydrogen has been detected in the compact HII region N81 (SMC) (ApJ 291, 156). A study of MC HII regions shows that the Hα luminosity function follows a power law and that the frequency distribution of nebular diameters is exponential with a scale length of 80 pc (ApJ 306, 130). Hα, Hβ fluxes of LMC HII regions have been used to model the extinction and reddening, some at least of which appears to be associated with the HII region (AA Suppl 62, 63; AA 155, 297).

Because MC PN are at known distance the resolution of their shells by speckle interferometry opens up important opportunities for nebular mass and age determinations. It is however a cause of some concern that for the one object (SMC N2) wich has been independently studied by two groups, quite different results have been obtained (ApJ 311, 632; MN 223, 151). Earlier, high masses of the central stars of three bright MC PN have been revised downwards and are now similar to estimated masses of galactic PN (ApJ 313, 268; MN 223, 151; AA 138, 317). Analysis of new PN radial velocities implied 9.10^8 $M_{\odot}$ within 3 kpc of SMC centroid. There is an excellent correlation between expansion velocity and excitation class for SMC PN wich may be traced to a correlation of these quantities with the mass of the central star (ApJ 296, 390). Ten new SMC PN were discovered (MN 213, 491). Some extremely energetic LMC PN are found to be bipolar. They may represent the upper end of the mass range of PN precursor stars and are perhaps related to symbiotics and such galactic objects as OH 0739-14 (ApJ 297, 593). The MC are crucial to studies of SNR and much work in this field continues; new SNR have been found (ApJ Suppl 58, 197) and detailed studies made of some of these (AA 164, 26; ApJ 314, 103). Observations (ApJ Suppl 51, 345; MN 216, 365) suggest that MC SNR are in free, rather than in adiabatic (Sedov), expansion but this result has been attributed to selection effects (MN 209, 449; AA 157, 6). New and revised chemical abundances have been obtained for LMC SNR (MN 216, 365; AA 174, 5). An earlier result (Obs 104, 193) that A_V/E_{B-V} in the SMC is close to the galactic value, has been confirmed (AA 149, 330; MN 211, 895). The ultraviolet extinction curve in the 30 Dor region of the LMC is distinctly different from that in our galaxy. Differences, though present, are less significant for the LMC outside 30 Dor (AJ 92, 1068; ApJ 299, 219; 288, 558). The diffuse interstellar band at 4430A is present in reddened SMC stars both with and without the 2200A feature suggesting that 4430A is not directly associated with graphite (MN 215, 5p). IRAS cirrus near the LMC coincides with galactic nebulosity previously identified by the Vaucouleurs and Freeman (MN 221, 543).

IV. STELLAR CONTENT AND EVOLUTION

The outburst by a known precursor (a B3 supergiant) at a known distance with intense optical observations beginning within 18 hours of the initial rise and preceeded by a neutrino bursts makes SN 1987A in the LMC an object of major importance. The behaviour has been in many respects unexpected and the results will have a major impact on SN theories. Many observational and theoretical papers are in press dealing with a variety of matters, from the extragalactic distance scale to the mass of the neutrino. It has been suggested that this star evolved to a SN without being a red supergiant and that energy fed into the system from a millisecond pulsar could explain the gradual rise in bolometric luminosity over a period of ~100 days. During the period under review one nova was discovered (SMC) (I.A.U. Circ. 4283, 4290, 4299).

The MC are the most favourable place for the study of the evolution of massive stars. The S Dor variables and other hot emission line objects of high luminosity (including B[e] stars) are of particular interest in this connection and the intensive study of these objects has continued, mainly by the Heidelberg group (AA 140, 459; 143, 421; 153, 168; 154, 243; AA 158, 371; 164, 321; 153, 163; 164, 435; AA Suppl 61, 237). The observations suggest a two-component stellar wind model for the B[e] stars. In a number of LMC emission line stars (including S Dor variables) [NII] and other nebular emission lines have been found, suggesting the classification of these objects as "supergiant PN" (similar to the galactic object AG Car). Further evidence has been obtained (ApJ 293, 407; AA 148, 379) for lower mass loss rates from MC blue supergiants than from those in our galaxy. Such results are explicable in terms of a lower metallicity (AA 173, 293). A comparison of Kurucz models with parameters of LMC B supergiants suggest that the late B stars are considerably less massive than expected from evolutionary theory. This may indicate mass loss during a long-lived hot supergiant phase (ApJ 312, 596). Equivalent widths of lines in galactic and LMC B supergiants have been compared. HeI lines appear weaker at a given class in the LMC (MN 210, 131). A very hot, massive O star in an LMC HeIII region may be evolving to the left of the main sequence (AA 170, L4). Extreme B stars range up to $M_V \sim -6$, brighter than anticipated from galactic work (AJ 90, 2009). There have been analyses of a number of spectroscopic binaries (PASP 96, 81; ApJ 310, 715). WR star research depends heavily on MC work and activity continues in this field including the discovery of new members of the class, analysis of binaries, and the discussion of individual stars including a possible WR runaway star in the LMC and the presence of a WN star in an old association implying a low (~20 $M_\odot$) mass (AA 173, 405; 149, 213; ApJ 300, 379; 292, 511; 309, 714; PASP 96, 968; MN 216, 459 see also 30 Dor above). Some general aspects of the WR problem are reviewed by (PASP 97, 5).

Reid, Glass and Catchpole (preprint) have discovered more Miras in the LMC and studied them in the infrared. They discuss the possible age distribution of these objects. Extensive SAAO infrared work on MC Miras is being analysed. The Mira P-L relation in the LMC is very narrow (Glass + Calgary Workshop. Ast. Sp. Sci. Library 132 p 51). The 200-day LMC Miras have a velocity dispersion of 30 km s^{-1} (ApJ 310, 710). They therefore constitute a population wich is less flattened to the LMC plane than young objects, and probably also less flattened than the LMC PN wich must be primarily old objects (note that in our own galaxy, 200-day Miras also constitute a flattened, rather than halo, population). The red giant population (AGB etc.) in the LMC has been discussed in relation to evolutionary models and dredge-up processes (ApJ 299, 236; 284, 98; 294, L7). Objects similar to galactic supergiant OH/IR sources have been identified from IRAS and ground based infrared observations and one found to show OH masing. In general the OH intensity of these objects appears lower than in galactic supergiant OH/IR stars (ApJ 302, 675; 306, L81). Amongst basic data published are colours, spectral types and luminosities of MC M supergiants (ApJ Suppl 57, 91; ApJ 289, 141) and the first part of a GRISM survey for C stars in the SMC (AA Suppl 65, 79).

Superluminous giants (SLG) were reported some years ago in young MC globular clusters and have been discussed in the past as post-AGB stars. It now appears that most, or all, of these are either non-MC members or blended images of more than one star (AJ 91, 80; 91, 1136). The research for, and study of protostars and related objects has continued (MN 219, 603; 215, 103; AA 140, 67). Considerable reference to star forming regions in MC is made in I.A.U. Symposium 115 whilst luminous stars are disscussed in I.A.U. Symposium 116. Some stars in the nebulosity N70 (LMC) may have circumstellar dust shells (AA 148, 397). Cepheid period changes have been discused and found to be primarily non-evolutionary in nature (MN 212, 395). Short period Cepheids and RR Lyrae stars in the direction of the LMC were also studied (ApJ 299, 728) some of these are probably foreground objects. An attempt has been made to systematize the nomenclature of MC objects (AA Suppl 64, 303; Bischoff, Strasbourg Circ.).

Helf and (PASP 96, 913) has given a general review of XR results in the MC. An 0.25 KeV survey of the LMC shows the emission to arise in two regions, Shapley III and the Bar (ApJ 313, 185). Optical pulses have been detected from the (Crab-like) 50 ms pulsar 0540-69.3 (ApJ 315, 142). Amongst other results are a suggested 164 day periodicity in the γ-ray burst source, GBS 0526-66 and the detection of an XR ionized He III region round the black hole candidate LMC X-1 (Nature 307, 41; 312, 737).

The initial mass function (IMF for MC massive stars is consistent with the Miller-Scalo IMF for the solar neighbourhood (ApJ 284, 565). Amongst relevant reviews are Garmany on the evolution of massive MC stars (PASP 96, 779), Frogel on some aspects of MC stellar populations (PASP 96, 856) and Wood on MC and stellar evolution theory (Calgary Workshop, Astrophys. Sp. Sci. Library 132). A number of workers have published population studies in specific MC areas. In the Wing of the SMC the IMF is relatively flat with an upper mass limit of 30 $M_\odot$ (AA 154, 249). In an LMC field the presence of disk and halo components has been studied and the disk found to be of constant thickness for stars ranging from M_V = -3 to +1 (AA 148, 263). A field at the periphery of the SMC shows two populations one of age 3.10^9 year and one (halo?) of age at least 5.10^9 year but younger than galactic globular clusters (MN 216, 165). The general ideas of self propagating star formation seem to satisfy results from Shaply III (LMC) (ApJ 297, 599; see also AA 150, 151) though it has been suggested that the overall distribution of LMC stars, dust and gas is not compatible with such a theory (AA 139, 115) and whilst interstellar matter and stars are well correlated in normal spirals, in the LMC they are not. BV magnitudes and positions for 1300 stars brighter than V=18.3 in a 0:02 sq. degree area of the LMC were tabulated (AA Suppl 61, 473). Contrary to previous work there now seems no significant evidence for runaway supergiants in the LMC. This places constraints on mechanisms for runaway star production (AA 152, 243)

9. Working Group on Galaxy Photometry and Spectrophotometry
(J.L. Nieto)

The field of photometry and spectrometry has benefited in the past three years from major technological advances in CCD technology, wich allow fast aquisition of more reliable and more accurate data. They yield automatic and accurate analyses of large galaxy samples and carefull detailed photometry of individual galaxies. This flow of CCD data has also forced photographic observers to produce higher accuracy data, a requirement that the development of sophisticated algorithms of image analysis has made possible. Targets were as usual, luminosity standards and other bright galaxies, but evidently also galaxies and components of galaxies, the analysis of wich has been facilitated by these improvements.

Several meetings took place during this triennum summarizing our present knowledge of the field: "The Virgo +cluster of Galaxies" (39.012.069), "New Aspects of Galaxy Photometry" (39.012.114), "Dark Matter in the Universe" (IAU Symposium 117), "Structure and Evolution of Elliptical Galaxies" (IAU Symposium 127, in press), "Nearly normal galaxies: From Planck Time to Present" (Eight Summer Santa-Cruz workshop, in press), etc.... A supplement to the bibliography on surface photometry of galaxies has been published by Pence and Davoust (39.002.044) (Further updates will be circulated through a mailing list). A paper reviewing technical aspects and results is in preparation (Okamura).

Kent: 167 galaxies of all morphological types (ApJ Suppl 56, 105) 37 Sb or Sc galaxies with optical rotation curves (AJ 91, 1301) and 16 galaxies with HI rotation curves (AJ 93, 816); van der Kruit (AA 173, 59): 51 disk galaxies; Michard (AA Suppl 39, 205), Lauer (ApJ Suppl 57, 473), Djorgovski (Thesis, Univ. of Calif.), Jedrzejewski (MN 226, 747): respectively 39, 42, 262, and 49 early-type objects; Schombert (ApJ Suppl 60, 603): 261 brightest cluster members; Ichikawa (ApJ Suppl

60, 475): 69 dwarf ellipticals in Virgo; Pierce and Tully (1987 in prep.): 300 nearby galaxies. Their aim is essentially to discuss light profile decomposition, notably in terms of ($r^{1/4}$) spheriod + (expotential) disk models, even for E's (Kent, ApJ Suppl 53, 115; Kodaira +, ApJ Suppl 62, 703; see also Schombert + AJ 92, 60). Analysis of published and new data led Simien and the Vaucouleurs (ApJ 302, 564) to discuss systematics of bulge-to-disk rotations. However severe difficulties regarding the laws used in these decomposions were raised by Simien and Michard (39.157.291) and Capaccioli + (preprint).

Very carefull (often multicolor) studies brought new insights on galaxies in very small samples or considered individually. These comprehensive analyses were made either from photographic (often Schmidt) material (e.g. Pence and de Vaucouleurs, ApJ 298, 560; Baumgart and Peterson, 41.157.051; Walterbos and Kennicut, AA Suppl 68, 311; Carigan, cited below; Prugniel + AA 173, 49; Hamable and Wakamatsu ApJ Suppl 56, 283; Duval and Monnet, ApJ Suppl 61, 141; Buta, ApJ Suppl 61, 609; de Carvalho and da Costa, AA 171, 66; Forte, AJ 92, 301; Wevers + AA Suppl 66, 505) or with CCD data (e.g. Daly + AA Suppl 68, 33; Davis + AJ 90, 169; Boroson and Thompson AJ 92, 33) or, notably for large galaxies, with both CCD and photographic data (Rampazzo, Thesis, University of Padova). In particular, Capaccioli + (preprint) have analysed in great detail the luminosity standard NGC 3115 relying upon a large colection of photographic (including Schmidt) plates and CCD frames, permitting them to cover a very wilde dynamic range.

It is especially in the field of elliptical galaxies that these new accurate data have brought new insights. indeed not only were new photometric properties discovered, but also very informative structural details on their origin and evolution were unraveled, notably dustlanes, disks, shells, boxy isophotes. Further discoveries after IAU Symposium 127 (mid-1986) (Carter ApJ 312, 514; Fort + ApJ 306, 110; Prieur, ApJ preprint; Rampazzo, cited above; Dettmar and Wielebinski, AA 167, L21; Mollenhoff and Bender, AA 174, 63; Bender and L Mollenhoff, AA 177, 71; Jarvis, ApJ in press) deserve attention as samples become increasingly larger and allow searches for correlations with other quantities. The origin of such features is mainly discussed in terms of formation of Es through mergers. Catalogues of dusty E's are being updated by Ebneter and Ballick (AJ 90, 183) and Zeilinger (Thesis, University of Vienna). A compilation of E's with emission lines was made by Bettoni and Buson (AA Suppl 67, 341). New properties brought out by the geometry of E's are discussed by Lauer (MN 216, 429), Jarvis (AJ 91, 65), etc... Notably Michard (AA 140, L39) stressed the analogy between the ellipticity profiles of elongated Es and SOs. The two-dimensional light decomposition of NGC 3115 (Capaccioli +, cited above) prompted the study of disks in SOs (Capaccioli +, preprint): they show an increase of thickness with distance unlike spirals that exhibit a constant scale height.

The correlation of L with color and metallicity for E's has been studied by Pickels and Visvanthan (ApJ 294, 134) and Pickels (ApJ 296, 340) with the population synthesis technique. The stellar content of E's and SO's was investigated notably by Carter + (ApJ 311, 637), Rocca-Volmerange and Guideroni (AA 175, 15) and Kjaeraard (AA 176, 210). The earlier discovery of a correlated scatter in the L-σ and L-Mg_2 relations has stimulated a series of papers whose aims are to investigate the nature of the second parameter discribing Es (Burnstein +, preprint and accompanying papers; see also Djorgovski cited above). Metallic linestrength profiles themselves have been investigated by Efstathiou and Gorgas (MN 215, 37p), Gorgas and Efstathiou (1987, in press), Baum + (ApJ 301, 83). The question of possible physical relations existing between normal Es and E-like systems has been addressed by several authors. Lachièze-Ray + (AA 150, 62) and Lauer (ApJ 311, 34) found no evidence for multiple nuclei to be merging with the cD galaxy NGC 6166. Different observational arguments suggest that dwarf spheriodical systems are not the low-mass end of the luminosity distribution of Es (Wirth and Gallagher, ApJ 282, 85; Kormendy, ApJ 295, 73); Bothun, AJ 92, 1007; see also Ichikawa, cited above).

Probably because spirals are better understood than early-type objects, they were less studied - observationally at least - during this triennum. However crucial problems deserve continuous attention, namely Freeman's constant (van der Kruit, AA 173, 59) and dark matter especially for edge-on and elongated (Meisels, AA 145, 138; Skrutskie +, ApJ 299, 303) and pure-disk spirals (Carignan, ApJ Suppl 58, 107; ApJ 299, 59; Carignan and Freeman, ApJ 294, 494).

Among irregulars, blue compacts stil have special place (Zamorano and Rego, AA 170, 31; Loose and Thuan, ApJ 309, 59), as well as those objects called UV-excess (Maehara +, PASJ, in press; Kodaira +, PASJ, in press) or starburst (Johansson, AA, in press), but this triennum has seen a special interest for ring-galaxies (Wakamatsu +, AJ 92, 700; Bonoli, AA 174, 57; Brosch, AA 153, 19; Schweizer +, ApJin press; Buta, ApJ Suppl, 61, 609; 61, 631 and preprints; sealso a review on rings and shells by Athanassoula and Bosma, Ann. AA 23, 147). Other intersting studies of pecular galaxies were carried out by Noreau and Kronberg (AJ, 92, 1048) and Karachensev + (MN 217, 743), etc....

The photometric profiles of the central regions have received special attention. A black hole has been suggested in M32 by Tonry (ApJ 283, L27). Lauer (ApJ 292,104) from deconvolution procedures and Kormendy (ApJ 292, L9) from high resolution data have found that (early-type) galaxies have non-isothermal cores, either due to velocity anisotropies or black holes. The nucleus of M31 has been also discussed in these terms (Nieto, ApJ 108, 111; Nieto +, AA 165, 189; Kormendy, IAU Symp. 127, in press) as well as the central regions of NGC 3379 and M81 (Bendinelli +, AA 140, 174; Parmeggiani, 39.157.125).

Photometry and spectrophotometry have yielded quite interesting results in the UV (e.g. Ciani +, AA 137, 223; Bohlin +, ApJ 298, L37; Donas and Deharveg, AA 140, 325; Israel +, AA Suppl 66, 117) or in the (near) IR (e.g. Frogel, ApJ 298, 528; Hunter and Galagher, AJ 90, 1457; Martinez +, AA 161, 237; Burkhead +, AJ 91, 777; Giles +, MN 218, 615; Adamson +, MN 224, 364). IRAS observations have brought new insights on star forming regions in galaxies (e.g. AA 154, 373; MN 218, 19P; ApJ 303, 171; ApJ 304, 651) and stimulated further IR investigations from the ground on stellar content and formation (e.g. Morwood +, AA 160, 39; Neugebauer +, AJ 93, 1057; Carico +, AJ 92, 1254) and on galactic evolution and activity (see Schweizer, Science, 231, 227).

Several papers have brought still usefull photoelectric photometry data (Lauberts, AA Suppl 58, 249; 68, 15; Véron-Cetty, AA Suppl 58, 665; Poulain, AA Suppl 64, 225; Bergvall and Olfsson, AA Suppl 64, 469; Peterson and Baumgart, AJ 91, 530; Gallagher and Hunter, AJ 92, 557; Burnstein +, cited above; see also Lucey, MN 222, 417 for a discussion on the L-σ test). A large copilation of such measurements has been made by Lauberts and Saddler(39.002.054).

Improvements in CCD technology should allow progress in the near future in several respects. A higher accuracy in photometric measurements and colors has already been reached with scanning CCD data (Boroson and Thompson, cited above) in the continuation of a previous study in this mode; only sky fluctations seem to limit the accuracy of such data, and no longer the pixel-to-pixel variations. Field limitations are starting to be overcome with CCD mosaics, allowing larger field-studies (Cohen, AJ 92, 1039).

This report is intensionally limited to a) non-active galaxies (Active galaxies are discussed in another report), b) bright galaxies. However, new frontiers have been reached as far as very deep photometric measurements are concerned. Faint galaxies have been measured with photographic plates (e.g. Koo, ApJ 311, 651) and with CCDs (e.g. Schneider +, AJ 92, 523). The latter however have brought very spectacular results: Djorgovski and Spinrad (ApJ 1987, preprint) have extended the Hubble diagram in the B, V, R, up to z=1.82, while objects as faint as the 27th

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magnitude in the V band have been detected with chopping techniques cancelling low-level systematics (Tyson, JOSA, 3, 2131). Note also an attempt of measuring redshifts of 22th mag galaxies from multicolor CCD photometry (Loh and Spillar, ApJ 303, 154) and the very powerful technique of multi-aperture spectophotometry (Soucail +, AA, preprint) applied to derive magnitude and redshifts of a large number of faint galaxies in clusters through metallic masks (Mellier +, AA, preprint). There are all the reasons to believe that these permanent technological improvements wil continue in the next years and yield fundamental discoveries on the structure, the formation and the evolution of galaxies.

10. Working Group on International Motions in Galaxies (C.J. Peterson)

Over the last three years, the major portion of the work of several hundred publications on international motions in galaxies and their interpretation has continued to be the accumulation of data from optical and radio studies, for individual galaxies as well as in more extensive surveys of larger samples of galaxies selected for a wide variety of reasons. Major stimuli for continued study have been the desires to clarify the relationship between kinematical and morphological properties of galaxies (Whitmore ApJ 278, 61), the use of such relationships (Tully-Fischer, Faber- Jackson) for distance determination (for E galaxies, see Dressler + ApJ 313, 42; Djorgovski + ApJ 313, 59; for spirals, see Giraud AA 155, 283; ApJ 301, 7 and ApJ 301, 7), and especially the improvement of observational constraints on dark versus visible matter (e.g. Kent AJ 91, 1301).

A major highlight of the past three years is the progress that has been achieved in obtaining high quality data to ascertain the range of galaxy kinematical properties and their relations to other physical parameters. As part of a long-term study on the kinematical properties of disk galaxies, Burnstein and Rubin (ApJ 297, 423) have analyzed rotation curves of 60 Sa, Sb, and Sc galaxies to conclude a) that galaxies of very different optical morphology and luminosity can have simular rotation curves, and b) that derived mass distributions for most galaxies fall into three well-defined integral mass types. The form of the mass distribution does not correlate with Hubble type or with Bulge-to-disk ratio, mass or mass density, size or any other global property of the galaxies. Burnstein + (ApJ 305, L11) also have shown that rotation curves of 20 galaxies in large clusters provide evidence for dependence of the distribution of mass types not on environment, but on Hubble type. Rubin and Graham (ApJ 1987) are now studying high-resolution rotation curve data to probe the distribution of matter at small radial distances from the nuclei of spiral galaxies.

Analysis of kinematical data for the shape of the gravitational potential in most disk galaxies is model dependent, but polar-ring galaxies provide a rare circumstance for assessing the distribution of dark halo perpendicular to the galaxy disk. Whitmore + (ApJ 314, 439), comparing disk circular velocities to the rotational motions in the polar rings of three galaxies, show that the gravitational well is essentially spherical. The origin of polar rings has been addressed by Whitmore + and also by van Gorkom + (ApJ 314, 457).

Barred galaxies continue to be of interest. Davoust (37.151.092) has produced a comprehensive review of kinematical and dynamical models for barred systems and Pfenniger (AA 141, 171) has produced new models. Teuben + (MN 212, 257), from numerical integration of 2-dimensional orbits, have constructed dynamical rules wich barred spirals theoretically obey. Schwarz (MN 209, 93) has studied how galactic disks are affected by bar strength and pattern speed. Observational studies have appeared for NGC 1097 and 1365 (van der Hulst 37.157.043), NGC 6221 (Pence + MN 207, 9), NGC 7496 and 289 (Pence + MN 210, 547), NGC 1365 (Jorsater + AA Suppl 58, 507 and AA 140, 288), NGC 3359 (Ball 39.157.246), NGC 7741, 3359, and 7479

(Duval + AA Suppl 61, 141), NGC 1566 (Beckman + AA 157, 49), and NGC 3992 and 4731 (Gottesman + ApJ 286, 471). Tremaine + (ApJ 282, L5) have proposed a combined kinematical/photometrical technique for measuring the pattern speed in barred galaxies; this has been applied to an SBO galaxy by Kent (AJ 93, 1062).

Elliptical galaxies also have continued to be of interest as their true shape is still not known; at least three tests have been proposed wich might indicate the true shapê of ellipticals. Biney (MN 212, 767) has suggested a test for triaxiality by comparison of rotational velocities along the major and minor axes; the test has been applied to observational data for 10 galaxies. Capaccioli + (MN 209, 317) have tested ellipticals by consideration of the correlation of velocity dispersion with ellipticity. Wyse + (ApJ 286, 88) have proposed consideration of mean surface brightness versus rotation as means of obtaining information on the true shape of a galaxy. Davies + (ApJ 303, L45) have studied the E2 galaxy NGC 4261 for which the rotation implies a prolate object. From study of extended gaseous emission in the E4 NGC 7097, Caldwell + (ApJ 305, 136) have referred the existence of a dark matter halo. More interest has been shown for peculiar elliptical galaxies. The kinematics of NGC 5128 have been studied by Wilkinson + (MN 218, 297) who have determined a relatively slow rotation of the stars perpendicular to the dust lane and by Hesser + (ApJ 303, L51) who have obtained data on the globular cluster Davies + (40.158.205) and van Gorkom (AJ 91, 791) have studied NGC 1052; the misalignment of the stellar and gas kinematical axes implies a recent capture for the gaseous material. Mollenhoff + (AA 154, 219) have surveyed dust lane elliptical galaxies.

An increasing amount of data is being obtained via conventional Fabry-Perot observations applied to the hydrogen emission lines, for example, the work of Buta (cited below), and other studies on NGC 300 (Marcelin + AA 151, 144), NGC 3109 (Carignan, ApJ 299, 59), and the Vela ring galaxy (Taylor + MN 208, 601). Fabry-Perot line reconstructions techniques (TAURUS) will be of increasing importance in the future. Studies have already been done, for example, in NGC 5642 and 7582 by Morris + (MN 216, 193) and for M83 by Allen + (39.157.019, 40.157.166, and Nature 319, 296). The use of emission lines from CO is also beginning to be exploited for kinematical purposes, as, for example, in studies of M51 by Rydbeck + (AA 144, 282) and the SBc galaxy NGC 5383 by Ohta + (P. Japan 38, 677).

Of the many other studies made on other galaxies, a number deserve specific attention. Giovanelli + (ApJ 301, L7) have studied UGC 12591, an SO/Sa galaxy with the largest rotation velocity (500 km/s) yet observed in a disk galaxy. Buta (ApJ Suppl 61, 609; 61, 631; 64, 1; and in press) has observed the rings in normal galaxies and argued that the strong case exists for a link between rings and orbital resonances in a bar. Jarvis (ApJ, in press) has investigated the box-shaped SO galaxy IC 3370, wich shows cylindrical rotation to a height of $8(50/H_0)$ Kpc above the plane in the agreement with predictions of theoretical models (May + MN 214, 131 and Binney + MN 214, 449). The motions of the nuclear gas in M31 have been considered by Boulesteix + (AA, in press) and Goas + (ApJ 297, 98), respectively. A comprehensive high resolution 21 cm survey of M31 has been presented by Brinks + (AA Suppl 55, 179 and AA 141, 195). Tonry (ApJ 283, L27) has given kinematical evidence for a central mass concentration in M32. Jarvis + (ApJ 295, 324) have investigated the dynamics of the bulge components of two spiral systems, NGC 7814 and 4594; the bulge of NGC 7814 has been similary studied by Bacon (AA 147, L16).

While the emphasis of the Working Group has traditionally concentrated on observations, advances in theory and theoretical interpretation of data cannot be ignored and a few items must be mentioned here. Of especial interest are the self-consistent N-body experiments of Smith and Miller (ApJ 309, 522) which produce model galaxies with flat totation curves. The linear programming technique of Schwarzschild for producing self-consistent galaxy models is being exploited by Richstone and collaborators (ApJ 281, 100, ApJ 286, 27, ApJ 296, 331, ApJ 295, 340 and 349, ApJ 296, 370). This method also has been applied by Schwarzschild (ApJ 31,

511) to galactic bars and by Vandervoort (ApJ 287, 475) to spherically symmetric galaxies. In other work, Martinet (AA 1987) has investigated the instabillity of radial periodic orbits along the rotation axes of bulges, spheroids, and rotating triaxial ellipsoids by numerical experiments in realistic gravitational potentials.

Several useful reviews appeared in this last triennial period. Athanassoula + (Ann Rev AA 23, 147) have reviewed rings and shells in galaxies. Pismis (41.157.263) has discussed the general kinematical properties of spiral galaxies. Efstathiou + (37.157.004) have reviewed rotational properties and the origin of rotation via tidal torques. The kinematics of the Magellanic Clouds and the LMC-SMC Galaxy interaction was reviewed by Freeman (37.156.030). A comprehensive discussion of the historical development and current understanding of galactic properties, concentrating on work by Carnegie astronomers has appeared as How Galaxies Rotate: Clues to Their Past? (Carnegie Inst. Perspectives in Science #2, 1986).

Finally we mention several catalogues that will serve as valuable guides to the available literature. Two compilations of velocity dispersion data have appeared: Whitmore + (ApJ Suppl 59, 1) have compiled 1096 central velocity dispersion measuremants in 725 galaxies; of these, 51 with at least three concordant measures are defined as standard galaxies. The Davoust + (AA Suppl 61, 273) catalogue tabulates 880 measures in 546 galaxies; systematic corrections are applied to yield a homogenous set of data. A catalogue of rotation curves for 116 galaxies has been prepared by Kyazumov (38.157.097).

This review of the literature of the past three years shows that study of internal motions in galaxies remains a very active endeavor at this time. The field wil remain active as the investigators move to refine and exploid the use of kinematical properties (both rotation curves as well as internal velocity dispersions) as an alternative method for distance determination to explore the local distribution and motions of galaxies and to improve the determination of the Hubble constant. Other questions of interest are the nature and distribution of dark matter, the true shapes of elliptical galaxies, and galaxy interactions and mergers. A significant increase in activity is promised in the near future as both the next generation of larger telescopes and the Hubble Space Telescope come into use

11. Working Group on Space Schmidt Surveys
(J. Lequeux)

The activity of this working group formed in 1976 has been very limited. In spite of the persisting need for a large-aperture, wide-field survey space telescope in the UV the chances for flying a long-duration mission of this type in a reasonable future look very small, and the technical studies have slowed accordingly. The existing ASTRO equipment contains a 38 cm imaging telescope with a 40 arc minute field and a 1.8 arc second resolution: this is a short-duration Space Shuttle mission wich unfortunatly will not fly before mid-89 but will give a first hint as to how the far-UV sky looks like at deep levels. For the moment, ballon flights are conducted succesfully by the Laboratoire d'Astronomie Spatiale at Marseilles at 2050A with a 39 cm telescope (2.3° field, 20 arcsecond resolution, intensified photographic detector). A 60 cm telescope with a 1° field and 5 arcsecond resolution using an existing 40 mm photon-counting detector has been proposed by a European collaboration to fly on the ESA EURECA platform (Astronomy version, flight duration 6 months); but the fate of this project is linked to the uncertain fate of the platform itself, which is related to the Space Station project. There is also a project in USSR for a 40 cm Ritchey-Chrétien telescope. Thus the present trend is towards more modest projects than the original 1 m Schmidt concept, but even those have an unclear future.

12. Working Group on Supernovae
(V. Trimble)

The supernova event of the triennium was, of course, 1987A. It will have aged by about a factor five between the writing and reading of these words, and many ideas will have changed. At the moment, we can say with some confidence that it occured (IAU Circ 4316) and showed the hydrogen lines of a type II (IAUC 4317, 4318). The optical light curve (IAUC 4316, 4320, 4329, 4330, 4333, 4348, 4377, 4388) was unprecedented (IAUC 4359), with very rapid rise, brief dip, and smooth linear increase lasting about 60 days before leveling off. The optical light was variable polarized (IAUC 4319, 4328, 4337, 4339, 4340, 4358, 4361) and reddened very quickly (IAUC 4320, 4325, 4326, 4328, 4332, 4338), energy shifting out of the UV (IAUC 4317, 4320, 4320, 4327, 4330, 4348, 4367, AApLett 1 May) and into the IR (IAUC 4347, 4351, 4353, 4354, 4368, 4370, 4374,) at the same time. Optical color plateaued and the UV began to cover as the ligh curve flattened (IAUC 4341, 4369, 4377). A radio outburst was much fainter and shorter-lived than those associated with more distant SNe (Nature 327, 38). The spectrum has evolved in complex ways and shows much structure due to absorbtion in interstellar gas in both galaxies (IAUC 4320, 4323, ESO Messenger No 47, AAp Lett 1 May). The gas velocity was initially at least 17,000 km/s but dropped rapidly (IAUC 4320, 4326, 4331, 4336, 4342, 4352, 4361). SN 1987A emitted neurinos in one or two bursts (IAUC 4323; PRL 58, 1490 & 1494) whose temporal pattern constrains the rest mass of the electron neutrino to <10-15 eV (PRLJ 58, 1906; Nature 326, 476). X-ray and γ-ray detectors had yield only upper limits (e.g. 0.4 mCrab and 0.3 $\gamma/cm^2.s$) up to day 90 (IAUC 4336, 4365, 4367, 4387). The progenitor was almost certainly a B3Ia star previously catalogued as Sk-69^0 202 (IAUC 4317, 4366, 4325, 4333, 4349, 4356). There is a compact HII region nearby (IAUC 4376), and early speckle work shows the SN itself unresolved at 0".015 (IAUC 4369, 4389), but there seems to be a 7 m object of uncertain nature 0".06 away i PA 194° (IAUC 4382, 4391). Models of the progenitor's evolution and the explosion process are exceedingly numerous, but largely still in preprint form.

On other fronts, the Berkeley automated supernova search found its first three events, 1986 I, N, and O (IAUC 4219, 4287, 4298), two of them early enough for important follow-up work to be done. Robert Evans continued to find SNe by visual methods, including 1986G in Cen A (IAUC 4208) which will surely be the most underappreciated supernova in history, 1987B! (IAUC 4321). The triennium also saw a probable SN in a QSO host galaxy (ApJ 291,L37) and one in a Seyfert (ApJ 293, L77)

Theorists continued to try to understand how energy from core collapse manages to eject Type II envelopes and to identify suitable progenitors for the nuclear detonations/deflagrations that are thought to make Type I's (Ann. Rev. AAp 24, 205). An unassisted core-bounce shock has great difficulty in getting out (Prog. Theor. Phys. 71, 524; Comm. 10, 149; ApJ Supp 58, 711; ApJ 299, L19). Among possible SNI progenitors, there are problems both with cataclismic variables (ApJ 279, 166; 283, 241) and with merging white dwarf pairs (AAp 150, L21; ApJ 297, 53; ApJ 308, 161; MN 223, 319; ApJ 315, 229; ApJ 316, 733). The neutrino cooling of a newborn neutron star has been calculated (ApJ 307, 178), and the possibility that Type II with linear light curves might be powered by nuclear rather than gravitational energy has been explored (AJ 90, 2303). Shklovskii's suggestion (Sov AJ Lett 10, 302) that we see no SNII's in irregular galaxies because the low metallicity does not permit development of the extended envelope needed to make the light curves looks remarkably prescient given the properties of 1987A.

Meanwhile, back at the telescope, radio detections became sufficiently numerous for subtypes to be categorized (ApJ 285, L85; Sci. 321, 1251; ApJ 293, 400). M82 revealed a population of compact, variable radio sources that are arguably young SNe and SNR's (MN 211, 783; ApJ 291, 693; Sci. 227, 28); and a simular population may have been seen in NGC 3448 (AJ 93, 1045). The curious proto-type V, 1961V, is apparently still present at radio and optical wavelengths (ApJ 297, L29 & L33; PASP 98, 467)

A new subtype, generaly called Ib, was defined (ApJ 294, L17; AA 149, L7; ApJ 306, L77; AJ 91, 691; MN 200, 27p; ApJ 313, L69; ApJ 317, 1 June). Its members differ from the class Ia's in lacking spectral feature at 6115 and 6855 Å, in being more likely to emit detectable radio fluxes while being $1^m.5$ fainter and more likely to be associated with young stellar populations, and, in one case, in showing spectroscopic evidence for about 0.3 M_0 of Fe (MN 218, 93). They have been modeled as comming from massive Wolf-Rayet progenitors (ApJ 302, L59; AA 167, 265 & 274; ApJ 316, 231), from Helium white dwarfs (Sov AJ Lett 12, 152), from WD mergers (ApJ 304, 201; ApJ 305, 225), WD + RG binaries (AA 164, L13), and Helium star binairies (ApJ 310, L35)

The relative rarity of associations between SNR's and neutron stars continues to puzzle (Nature 307, 215; Comm. 11, 15). Evidence has accumulated for significant gas ejection just prior to SN explosions, presumably in a superwind (PASP 96, 789; ApJ 288, L17). And supernovae are proving a useful tool for probing the interstellar medium of other galaxies (ApJ 281, 585).

Finally, a number of lines of both observational and theoretical evidence have begun to suggest that standard supernova rates are overestimated by a factor of two or so, in M31 (AA 169, 14), the LMC (ApJ 281, L25), and elliptical galaxies (ApJ 213, 503), as well as in the Milky Way (Sov AJ 28, 137; AA 140, 431; MN 216, 691; ApJ 304, 657; ApJ 315, 555) for which the correct rate is probably about two per century, divided among Ia, Ib and II in the ratio 3:4:11 (van den Berg PASP in press 1987).

About 300 archival journal papers, many fine reviews, and half a dozen conference proceedings concerning supernovae appeared in English over the past three years. Only a very few of these could be mentioned, and many important topics are not addressed here at all. Please read the literature!