Commission 28: Galaxies

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This report covers the period 1 July 1990 to 30 June 1993. It has, as usual, been prepared by the commission officers and committee and chairs of the Working Groups. The usual problems of covering a broad subject accurately and fairly have been compounded by the present very difficult situation in the President's home country of Armenia. In particular, the section on Active Galaxies, which he had hoped to prepare, is missing; and we apologize to colleagues whose work has gone unrecognized in the circumstances. References are given in abbreviated form, with no initials or years of publication, and with a symbol + replacing the usual "et al."

1. Highlights since Buenos Aires
(V. Trimble)

Many discoveries during the triennium were exciting and do not require extended discussion for their appreciation. This is a subset.

The Local Group has a new member, a dwarf spheroidal in the direction of Tucana (Lavery & Mighell AJ 103, 81) but has lost And IV which is really just an open cluster or association within M31 (Joseph AJ 105, 932). Van den Bergh (MNRAS 255, 29p) had never actually admitted it to the canonical list. Meanwhile, the LC dwarf irregular IC L613 has revealed its population of old stars in the form RR Lyrae variables (Saha + AJ 104, 1068). And the nuclear radio source in M31, corresponding to our own Sgr A*, has finally turned up, though the radio remnant of SN 1885A remains among the missing (Crane + ApJ 390, L9).

Gas in galaxies can take many forms. We note here only the existence of a complete bibliography of CO (Verter PASP 102, 1281), a fine review of the issue of gas in ellipticals (Volkov Astrofiz 32, 80), and the fact that it is possible to remove HI from a spiral while retaining the molecular gas, resulting, for instance, in the "anemic spirals" of Virgo (Valluri & Jog ApJ 357, 367; Cayatte + AJ 100, 604).

The gassiest galaxy is arguable IRAS 10214+4724 ($z = 2.286$) with $10^{11}\ h^{-1}$ solar masses of H_2 (Downes + ApJ 398, L25). It may also have the highest star $M_\odot$ formation rate (Tsuboi & Nakai PASJ 44, L241), but could also be a superposition of two separate objects along the line of sight, one of them a dusty qso (Soifer + ApJ 399, L55).

Valentijn's 1990 proposal (Nature 346, 153) that spiral disks are so opaque that we miss enough light to remove the need for dark matter, at least in individual galaxies, continued to provoke puzzlement. The disk of the Milky Way near us is quite transparent — the model used for the HIPPARCOS input catalogue has $A_V = 0.1$ mag above $b = 60°$ (Arenou + A&A 258, 104) and A_B is only 0.16 magnitude to Andromeda (Jablonka + A&A 260, 97). But many spirals seem to have very opaque central bulges (Huizinga & van Albada MNRAS 254, 677; Cunow MNRAS 258, 251). And while the space-averaged disks may be fairly transparent (e.g. $A_B = 0.46$ mag full thickness, Peletier & Willner, AJ 103, 1761), the fact that both luminosity and dust are concentrated in spiral arms may mean that effective extinction may be more like a whole magnitude (White & Keel Nature 359, 129). But the real puzzle is that the absorbed visible light must come back out as infrared emission (Phillips + MNRAS 253, 496) and most spiral galaxies are not more luminous

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as IR sources than as optical ones.

Triggered star formation seems to be directly responsible for the high brightness of interacting galaxies. For instance, 60% of the brightest 10^{12} $L_\odot$) IRAS galaxies, but only 10% of the faintest ($L < 10^{10}$ $L_\odot$) appear to be interacting on ESO/SERC and Palomar sky survey images (Zou + MNRAS 252, 593) and pr. comm. from the same group. A sample of non-Seyfert Markarian galaxies also includes a large excess of close pairs (Keel & van Soest A&AS 94, 553). Radio emission from interacting galaxies is another symptom of vigorous star formation (Batuski + AJ 103, 1077). For IRAS interacting pairs, both galaxies typically show the high L_{FIR}/L_B ratio and infrared colors that are indicative of rapid star formation (Lutz A&A 259, 462). The same applies to other interacting pairs (Sekiguchi & Wolstencroft MNRAS 255, 581). The implication is that the detailed geometry of the encounter is not critical to triggering, though the morphology of the pair NGC 7714/7715 suggests that off-center encounters cause only core, not ring, star bursts. Other interesting specific cases include (a) the SMC whose youngest stars are mostly on the side toward the LMC (Gardiner & Hatzidimitriou MNRAS, 257, 195), (b) an interacting pair in the Bootes void with one starburst and one Seyfert 1 galaxy (Weistrop + ApJ 396, L23), (c) star formation caused by cannibalism of Cen A (Thomson MNRAS, 257, 689), and (d) two companions of M81, with about the same amount of gas, but very different star-formation rates (Thronson + MNRAS 252, 547; Keel & van Soest, A&A 94, 553).

Galaxy formation is an unsolved problem elegantly reviewed by Peebles and Silk (Nature 346, 233). It may be a gradual process (Larson PASP 102, 709) or an explosive one (Yoshioka & Ikeuchi ApJ 360, 352). One is perhaps a bit surprised at just how little difference the measured anisotropy of the 3K radiation has made to the discussion. The data base already included large scale structure (superclusters and voids) with internal velocity dispersions of a few hundred km/sec, coherent streaming over regions of 100 h^{-1} Mpc or so with somewhat large speeds, and the existence of qso's at redshifts of nearly 5. Even before COBE, none of the simple models did a very good job of dealing with the full range (Efstathiou + MNRAS 258, p. 1). At most one can now say that a few additional combinations are ruled out (Blanchard + A&A 267, 11; Dodelson & Jubas PRL 70, 2224; Kashlinsky ApJ 399, L1; Cen & Ostriker ApJ 399, L113). Strings are in (Bennett + ApJ 399, L5), and textures are out (Holman + PRL 69, 1489). Strangely, and owing to marginal contradictions between the COBE fluctuations and stringiest upper limits to ones on smaller angular scales as probed by ground-based data, a cosmic background of gravitational radiation is also "in" (Davis + PRL 69, 1856; Lucchin + ApJ 401, L49; Crittenden + PRL 71, 324).

Primordial galaxies, in the sense of large, bright high-redshift (pre-qso) objects undergoing their first episode of star formation continue to elude detection in both redshifted Lyman α and redshifted 21 cm (Lowenthal + ApJ 357, 3; Subramanyan & Swarup A&A 11, 221; Cowie + ApJ 360, L1). Suggestions of new search strategies persist (Carr + ApJ 367, 420). It is also true that for a significant subset of the galaxy formation mechanisms referenced in the previous paragraph, no such entities ever arise.

The youngest galaxies are perhaps those dwarf irregulars just now forming from gas torn loose in close encounters of larger spirals (Amram + A&A 266, 106; Henkel + A&A 273, L15; Elmegreen + ApJ 412, 90).

The lowest metallicity galaxy has long been the dwarf irregular I Zw 18. Its metallicity of [Fe/H] = −1.6 (Campbell ApJ 362, 100) is at least rivaled by that of SBS 0335-052, a couple of Byurakan galaxies, and UGC 4483 (Terlevich). Talk at 21st IAU GA; Izutov + A&A 247, 303; Skillman PASP 103, 919). A regression of He/H on O/H or O/N in these low-metallicity galaxies leads to a new, lower primordial helium abundance, Y_p = 0.217 − 0.233, which is awkwardly smaller than expected from

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big bang nucleosynthesis in a homogenous universe (Matthews + ApJ 403, 65).

Dynamos of the self-excited $\alpha-\omega$ type have been the standard model for the origin of galactic magnetic fields for some time (Beck + IAU Symp. 140). Doubt has been cast on this conventional wisdom on both observational and theoretical groups. Wolfe + (ApJ 388, 17) find that galaxies at redshifts as large as z = 2 have fields about as strong as the Milky Way, meaning either that the field is largely primordial, or that a dynamo operated very rapidly. On the theoretical side, recent discussions suggest (a) that the most probable dynamo field geometry is not that seen most often in real galaxies (Elstner + ApJS 94, 587), (b) that most of the power quickly cascades down to small spatial scales, leaving no significant large-scale field (Kulsrud + ApJ 396, 606), while observations indicate roughly equal power on large and small scales (Jones + ApJ 389, 602), and (c) that galactic dynamos saturate at fields much smaller than the observed ones (Vainshtein & Cattaneo ApJ 393, 165). The alternative is a primordial field of sufficient strength that the observed ones can be produced form it by moderate amounts of winding and amplification. Possible sources for the necessary seed fields are vorticity in the early universe (Rebhan ApJ 392, 385) and inflation (Ratra ApJ 391, L1). I would probably find these more persuasive if I understood them better. Effects of star formation (Ko ApJ 360, 151) or an active galaxy phase (Daly & Loeb ApJ 364, 451) may be relevant.

Faint blue galaxies make up most of the fuzzy objects in the sky at $B_J = 24$, but not by $B_J = 22$ (Colless + MNRAS 253, 686). They typically have redshifts around unity (Cowie + Nature 354, 460; Tyson + ApJ 349, L1), and the shear numbers are rather mystifying (Ellis & Frenk Nature 346, 790). Only three sorts of answers are possible to the question, where have they gone? First, they have ceased to be blue and are now other kinds of faint galaxies. Second, they have ceased to be faint (by merging into the larger galaxies now seen). Or, third, they have faded completely out of local samples. All three have been proposed. Mergers of FBGs to the present population are favored by Guideroni and Rocca-Volerange (A&A 252, 449) on the basis of comparisons of blue and infrared counts and also by Broadhurst + (Nature 355, 54) who predict that the mergers should be accompanied by high star-formation rates at moderate redshift. In contrast, Lacey and Silk (ApJ 381, 14) propose that the modern forms will be stripped, low-surface-brightness galaxies in dense clusters and gas-rich galaxies with "retarded" star formation in the field. Babul and Rees (MNRAS 255, 346) propose nearly the opposite. Following a first star burst near z = 1, the FBGs in low-density environments expel their gas and so fade away, while those in clusters with high ambient gas pressure are unable to get rid of their gas. Thus they continue star formation somewhat longer, appearing now as the very extensive population of dwarf ellipticals characteristic of rich clusters (Binggeli & Cameron, A&A 252, 27). If Giraud (A&A 257, 501) is right that there are three physically distinct kinds of objects among the FBGs, then three different end points is not implausible. For one example, we apparently know the answer. An FBG on the line of sight to qso Pks 0454+0356 shows evidence of recent star formation, but no longer contains enough gas to impose an absorption line on the qso spectrum. It will, therefore, rapidly fade away (Steidel + ApJ 413, L77).

The largest-scale structures and deviations from smooth Hubble flow in the universe continue to be a topic of debate, but it is clear that homogeneity has not yet been reached at 100 h^{-1} Mpc (Broadhurst + Nature 343, 726; Picard AJ 102, 445; Bahcall ApJ 376, 43; Huchra + ApJ 365, 43). A candidate for the largest-scale streaming is the structure connected with the so-called Great Attractor. On beyond the local, Virgo, supercluster, recognized structures include major visible concentrations of galaxies in the Perseus-Pisces and Hydra-Centaurus regions, in roughly opposite directions in the sky, at distances of 3-5000 km/s. The surprise was that the Hydra-Centaurus galaxies were moving in the same direction as we are, implying a mass concentration (the GA) on the far side of them, but not as distant as the Shapley concentration on beyond at 14,000 km/s. It was expected that enlarged samples in several surveys would eventually all show the same structures with roughly the same degree of prominance. This has not happened. Some surveys have continued to show a concentration of galaxies in the vicinity of the GA (Scharf + MNRAS 256, 209; Strauss + ApJ 385, 421) or velocity streaming toward it from our side (Han ApJ 395, 75; Rauzy + A&A 256, 1). Others have found indeterminate results (Mould + ApJ 383, 467; Bothun + ApJ 388, 253). And some have found the GA unnecessary (Landy & Szalay ApJ 391, 494; Tully + ApJS 80, 479) even for the Seven Samurai's own data (Weigelt & Kates A&A 252, 1). Yet other investigations have concluded that the GA is actually forbidden, in the sense that galaxies in that part of the sky are not clumped at the right redshifts (Visvanathan & van den Bergh AJ 103, 1057) and that galaxies on the far side of the GA are not falling back into it toward us (Mathewson + ApJ 389, L5). The alternative is a bulk flow at about 600 km/s extending over a region 130 h^{-1} Mpc long, reaching from the GA across us and on to the Perseus-Pisces region, and perhaps beyond (Han & Mould ApJ 396, 453).

ROSAT has probably revealed a new class of X-ray clusters. Most of the well-known X-ray emitting clusters of galaxies are large and rich. The first of the new ones is a small group centered around NGC 2300 (Mulchaey + ApJ 404, 19). Surprises included the very large total mass, the low metallicity of the gas (about 6% of solar), and the very extended gas distribution. A Hickson compact group (HCG62) has turned up as the second such cluster (Ponman & Betrand Nature 363, 50). Two implications are that the cluster will merge (presumably to a giant elliptical galaxy with an enormous X-ray halo) in about 3 x 10^9 yr and that we would be in trouble with the nucleosynthesis limit to cosmic baryon abundance if all galaxies and clusters had as high a ratio of baryonic to total mass as this one does. Additional groups of this sort are in the unpublished data base (Hasinger IAU Symp. 161).

The triennium has seen detection of unexpectedly large numbers of active galaxies in two wavelength regions. First, owing to patchiness of the local interstellar medium, a few AGNs are part of the data base in the extreme ultraviolet from ROSAT (Pound + MNRAS 260, 77) and nine from EUVE, starting with Pks 2155-304 (Marshall + ApJ 414, L53). Of greater physical significance is the near-double-dozen of AGNs seen by EGRET on the Compton GRO. All show some sort of Blazar behavior (rapid variability, strong variable polarization, weak emission lines, Dermer & Schlickeiser Science 257, 1642). Virtually all models (e.g. Friedlander + AIP Conf Proc 280, Compton Gamma-Ray Observatory and the expected corresponding volume in AIP Conf series from the 1993 symposium) involve relativistic jets and strong beaming of the gamma rays, closely related to the strong beaming that makes the sources appear as Blazars in the first place. The closest source, Mkn 421 at z = 0.0308 has also been seen at TeV energies (Weekes + IAUC 5522). It is also the only one whose photons of such high energy can be expected to get through the sea of intergalactic infrared photons without colliding and being waylaid en route.

Alignments of the (presumably non-thermal) radio emission and (presumably stellar, thermal) optical emission of active and other galaxies at large redshifts was initially a considerable surprise. It is quite wide spread (McCarthy + AJ 100, 1014), and can include infrared emission (Chambers + ApJ 363, 21) and both line and continuous light (Eales ApJ 409, 578). The phenomenon is largely restricted to sources with the highest radio powers (Dunlop & Peacock MNRAS 263, 936). No less than five mechanisms have been proposed to explain such alignments (Daly ApJ 399, 426), of which the most straightforward are radio jet triggering of star formation and Thompson scattering of AGN core light by electrons in the radio jets. Optical synchrotron or inverse Compton emission in the jets themselves could also contribute, and I am pretty sure I don't understand the fifth one. Phenomena in nearby objects that seem to be analogous indicate that at least three of these do indeed occur. McNamara and O'Connell (AJ 105, 417) have found two cooling flow

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clusters of galaxies whose central galaxies have blue-lobe-shaped optical emission associated with the radio blobs. These argue for triggered star formation. The nearby Seyfert 1, Mkn 509, on the other hand, has its radio continuum, polarized H alpha, narrow line region, and optical and IR polarized continuum all more or less aligned. The combination strongly suggest that both scattering and synchrotron emission contribute to polarization at the same position angle (Singh & Westergaard A&A 264, 489).

QSO absorption lines have probably now been studied in enough different was that the territory has been fully surveyed (though many details remain to be painted in). Broad absorption lines with absorption redshift close to the emission one are produced in material closely associated with the qso itself, and the main dispute is whether the covering factor is small (Korista + ApJ 401, 529) or large (ApJ 413, 95). There are some data indicating that the BAL population is physically distinct (Boroson & Meyers ApJ 397, 442); Francis + AJ 106, 417. Metallic line and damped Lyman alpha lines are both produced in the gas in normal galaxies, the former in turbulent halo gas, the latter (along with 21 cm lines) in quiescent disk gas (Lu + ApJS 84, 1; Wolfe + ApJ 404, 480). The number of cases where the absorbing galaxy is seen independently continue to rise (Bowen & Blades ApJ 403, L55; Bahcall + ApJ 398, 495; Spinrad + AJ 106, 1; Moller & Warrent A&A 270, 43). And HST observations of absorption produced in our own Milky Way show that, on average, seen from far away, it would look very much like the qso systems (Savage + ApJ 404, 124 and 413, 116). The Lyman alpha forest comes from much smaller, less dense, lower-metallicity clouds. A major surprise was how many HST revealed at small redshift (Brandt + AJ 105, 831; Bahcall + ApJ 397, 68; Bahcall ApJ 405, 491; Bruhweiler + ApJ 409, 129), given how rapidly they "evolve" at higher redshifts (Frye + MNRAS 263, 575; Press + ApJ 414, 41). A continuing dispute concerns whether the clouds are confined by gravitational forces of "mini-halos" or by the pressure of a hotter surrounding intergalactic medium (Petitjean + MNRAS 262, 499; Miralda-Escude & Rees MNRAS 260, 617; Murakami & Ikeuchi ApJ 409, 42). In principle, both could happen, and the low redshift systems be different again (Charlton + ApJ 402, 493). Finally, continuous Gunn-Peterson absorption blueward of Lyman alpha in the qso rest frame has still not been seen (Giallongo + ApJ 398, L9). For further details on this topic, see Trimble and Leonard (PASP 106, 1).

The diffuse X-ray background was long the subject of debate on whether the primary emitter was diffuse intergalactic gas or a very large number of sources. Absence of distortion of the 3K spectrum as recorded by COBE ruled out hot gas (Rogers & Field ApJ 366, 22), focussing discussion on whether the sources were active galaxies of the sort seen around us or something else. When only a few X-ray spectra were known, it was difficult to tell whether they were typical or not (and if they were, the sum would not add up to the background). Ginga data (Morisawa + A&A 236, 299) now indicate that this is not a problem, because spectra harden above 10 keV, and statistical fluctuations across the sky at these energies (Martin-Mirones + ApJ 379, 507) also suggest resolution into sources with luminosities typical of AGNs. At 1-2 keV, the issue has been fully settled by resolving essentially all the background into individual sources in those fields where ROSAT has surveyed deepest (Hasinger + A&A 275, 1; Hasinger IAU Symp. 161). At least one model (Zdziarski + ApJ 414, L77) makes it seem reasonable that AGNs should add up to the background at all energies from 2 to 100 keV, and the same claim has been made for both gamma rays (Stechker + ApJ 410, L71) and the extreme UV (Denda & Ikeuchi PASJ 45, L1). Many other workers have claimed the opposite.

With Enrico Fermi, we find it difficult to make predictions, especially about the future. Nevertheless, it seems reasonable to hope that the next triennium will see (a) clarification of the issues connected with cooling flows in rich clusters (how much mass; where does it go) owing to the rich data base coming from ROSAT and ASCA, (b) a cleaner case of microlensing in a quasar than the classic objects 0957+561 (Falco + MNRAS 251, 698) and 2237+030 (Wambsganss & Paczynski AJ 102,

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864), permitting at long last the promised independent measurement of H_0. (c) A good description of the correlations between properties of populations of globular clusters and their parent galaxies, (d) a statistically significant set of normal galaxies with and without central black holes, and (e) a clearer impression of the extent to which the luminosity (or mass) function of galaxies is universal.

2. Astronomy in the Former USSR
(A. Zasov)

In spite of the highly unfavorable conditions for astronomical researches in the former USSR caused by severe economical crisis and disintegration of the country, extragalactic investigations still have been developed in their basic directions. Here we consider four fields of research: 1. Stellar populations and interstellar medium. 2. Structure and dynamics of galaxies. 3. Active nuclei and QSO's. 4. Systems of galaxies.

I. STELLAR POPULATION AND INTERSTELLAR MEDIUM

Sharov, Lyutyi and Ikonnikova have published their new results of UBV-photometry of 22 globular clusters of Andromeda nebula (Let in Russ AJ 18, 99). Star formation efficiency (SFE) in this galaxy was the subject of the research work of Kolotovkina (Let in Russ AJ 18, 760). She compared SFE in the arms near the major axis of the galaxy and in the interarm space using HII regions count. She concluded that there is no increasing of SFE in the arms with the exception of the arm S4, distinguished by its large pitch angle. The distribution of blue stars in M31 was investigated in relation to spiral arms and HII regions of the galaxy by Efremov, Ivanov, Nedialkov (AAp Trans 3, 237). They found that only in the S4 arm there is a stellar age gradient across the arm. The most probable value of the radius of corotation in M31 is about 15 kpc and certainly larger than 10 kpc. Sharov presented new estimates of Nova rates in the disk of M31, its companions M32 and NGC 205 and in M33 on the basis of the date obtained in Crimea and Latvia in 1967-1990 years. The new data confirm a strong difference between the specific Nova rates in the disk and in the bulge of M31. A low specific Nova rate was found for M33 (< 1.0 per yr per 10^{10} of solar lum.) (Let in Russ AJ 19, 287). The results of new spectral observations of inner parts of 12 galaxies of E-Sb types were presented by Sil'chenko, Afanasiev and Vlasyuk (Russ AJ 69, 1121). For 7 out of the 12 galaxies a metallicity jump was found between nucleus and bulge. The nuclei are found to be more metal-rich by 0.6-1.3 dex. Jumps appear to be related to nuclei, which are dynamically decoupled, being distinguished by their high angular velocity. A catalog of 147 stellar associations and aggregates in S-galaxy NGC 628 was presented by Invanov, Popravko, Efremov, Tikhonov, and Karachentsev (AAp Sup 96, 645). Catalog gives positions of associations, their size, integrated magnitudes and HII identifications. Authors point out that stellar associations form groups with a length scale about 600 pc (star complexes).

Several papers were devoted to dwarf galaxies. Distances to three nearby dwarf galaxies (Ho I and II, UGCA 105) were determined from photometry of their brightest red and blue stars by Tichonov, Karachentsev, Bilkina and Sharina (AAph Trans 1, 269). An essential discrepancy was revealed between the distance obtained for Ho I ($m - M = 29.11$) and previous estimates. The distance they found exclude belonging of this galaxy to M 81 + NGC 2403 + IC 342 group. The record metal-poor BCD galaxy SBS 0335-052 was found by Izotov, Lipovetsky, Guseva and Stepanian (Let in Russ AJ 16, 609). The oxygen and neon abundance in this galaxy are shown to be 1.3 and 1.9 times lower than in the well-known metal-poor dwarf galaxy I Zw 18. Piluigin (AApC 260, 58) show that the basic observed peculiarities of N-O abundances of dwarf Irr-galaxies can be well reproduced within the framework of closed box model of chemical evolution if to admit that the giant HII-regions in these galaxies are self-enriched. The results of spectrophotometric studies of 9 giant extragalactic HII regions in dwarf galaxies of M 81 group were presented by

Izotov, Guseva, I. D. Karachentsev, V. E. Karachentseva (AAph Trans 1, 283). The heavy elements abundance they found are 3 - 10 times lower than solar value and are quite typical for blue compact dwarf galaxies. Kritsuk (AAp 261, 78) presented model of evolution of the hot X-ray gas in halo of E-galaxies considering it as an open system with mass and energy sources determined by the stellar mass losses, SN and radiative gas cooling. Numerical simulations showed that in a reasonable domain of the parameters the stable periodic solutions exist, which describe cyclic process of gas accumulation and heating due to the stellar sources with subsequent gas cooling and dropping out of the halo. The evolution scheme of disk galaxies within the framework of a gas turbulence energy balance between the SN input energy and the turbulence collisional dissipation was proposed by Firmani and Tutukov (AAp 264, 7). The IMF, angular momentum and the gas accretion rate determine the evolution of the models. As a result, authors predict the present gas content and star formation history of a galaxy. Sokoloff, Shukurov, and Krause (AAph 264, 396) used two-frequency polarization observations of S-galaxies to get the general pattern of the magnetic disk field in IC 342 and M 81. Regular field (several microgauss) appears to be axisymmetric for IC 342 and bisymmetric for M81. The flow of interstellar gas in the gravitational field of galactic density waves has been investigated by Mishurov (AAp Trans 3, 317) in the framework of the diffuse approximation. The galactic density waves are shown to stimulate the formation of molecules of hydrogen. The proposed theory explains the existence of two displaced spiral systems, discovered in M 51 by comparing CO, dust, HI and other spiral tracers.

II. STRUCTURE AND DYNAMICS OF GALAXIES

The line of sight velocity of ionized gas at different position angles and the rotation curves of the inner parts of spiral galaxies were presented for NGC 497, 895, 972, 3646, 4100, 4536, 5351, 6181, 7171 and 7721 by Afanasiev, Burenkov, Sil'chenko and Zasov (Rus. AJ 68, 1134 and 69, 19). It was shown that the central regions (R < 1 kpc) of the most of these galaxies as for galaxies presented in previous articles by this group, have peculiar shape of line-of-sight velocity curves being distinguished from their surroundings by abnormally low or high velocity gradients or by the presence of the inner maximum on the rotation curve. These features give evidence of the existence of the central mass concentration or -in some cases -of small central bar. In addition, local systemic deviations from circular rotation curves with amplitudes about 30 km/s were found. For NGC 972, 4100, 4536 and 6181 noncircular gas flows were discovered far beyond their nuclei which envelop regions of more than one kpc scale. Rotation curves parallel with UBVR-photometry were obtained for several galaxies of type Sc - Irr (NGC 959, 1156, 1160, 6643 and 7292) by Esipov, Kyasumov and Jafarov (Rus AJ 68, 909). In the frame of simplest model it was shown that the central depression of thin axisymmetrical disk is needed to account for the shape of their rotation curves. Sil'chenko and Vlasiuk (Let in Rus AJ 18, 643) presented the results of axes orientation and ellipticity investigations for the central parts of 5 S-galaxies with known gas kinematics. In the inner regions of NGC 615, 7013, 7331 whose nuclei are dynamically decoupled by their fast circular rotation there are no turning of major axes of nuclear isophotes relative to the line-of-nodes of global galactic disks. On the other hand NGC 2655 and 7217 which are suspected to have strong non-circular gas motions in their nuclei, demonstrate such a turn. Therefore they apparently possess bar-like non-axisymmetrical bulges which provoke the non-circular velocity motions. The small mini-bar-like feature parallel with the inner ring structure was found in the center of nearby galaxy M 81 by Georgiev and Getov (Let in Rus AJ 17, 393) from their high resolution isophotes maps. Dimensions of these central structures are 0.64 and 1.50 kpc correspondingly.

A series of articles devoted to edge-on disk galaxies had been published for the last years. Karachentsev and Xu obtained rotation curves for 41 thin galaxies having axes ratio a/b > 7 (Let in Rus AJ 17, 321 & 485). More than 90% of the

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rotation curves have a non-decreasing shape and about a quarter of them may be classified as "wave-like" curves. The optical rotation curve amplitude demonstrates a tight correlation with the 21 cm line width. This allows to use the optical rotation curves for flat galaxies as a tool to determine their distances by analogy with the Tully-Fisher relationship. According to Karachentsev (Let in Rus AJ 17, 671) the main parameters of thin edge-on galaxies are typical for Sc-Sd galaxies. Outside the Local Supercluster the linear diameter of these galaxies produce a standard deviation about 20% as a distance estimator. Isophotal magnitudes of 120 northern thin edge-on galaxies parallel with their angular diameters, luminosity profiles and some basic photometrical parameters obtained from CCD- observations at R'-band have been presented by Karachentsev, Georgiev, Kajsin, Kopylov, Ryadchenko and Shergin (AAp Trans 4, 265).

The stellar disk stability analysis and N-body numerical experiments were carried out by Zasov, Makarov and Mihailova (Let in Rus AJ 17, 884) to find relationship between mass of the spherical component and minimal thickness of collisionless gravitating disk. They conclude that the observed disk thickness of edge-on galaxies may be used to estimate the halo-disk mass ratio. For the thinnest observed edge-on galaxies their halo should be at least twice as massive as the disk. Simakov (Let in Rus AJ 16, 679) considered dynamical evolution of the differentially rotating marginally stable protogalactic disk. Density distribution profile is shown to tend to quasi-exponential law in accordance with observations provided the typical gas viscosity time scale is comparable to the star formation time scale. In the framework of the Lin - Pringle model of the evolution of protogalactic gaseous disks he showed that angular momentum redistribution and star formation lead to certain value of the central surface density of the disk which should be a function of halo parameters (Simakov AAp Trans 3, 327). Chuvenkov, Glukhov and Vainer (Ap Sp Sci 190, 243) have computed the model of evolution of a disk subsystem of a spiral galaxy paying the main attention to the radial abundance gradient. It was shown that accretion of intergalactic matter onto the disk results in smoothing the radial gradient, especially at the late stage of the evolution. The final gradient depends weakly on the age of the galaxy. The best agreement between calculated and observed abundance of He is revealed if the primordial yield Yo = 0.25. A stellar-dynamical explanation of the observed morphology of barred galaxies have been proposed by Pasha and Polyachenko (Let in Rus AJ 19, 3). It emphasizes the role of the resonance disk response of stars on nearly circular orbits to a slowly growing potential of the Lynden-Bell bar. A theory developed allows one to derive a correct ratio for the observed diameters of outer and inner rings which should be close to 2.2. Inner rings surrounding bars in SB(r) systems are related to the ILR with a dominant m=2 bar-mode, and the outer rings - to the m=4 resonance. Morphological difference between the SB(r) and SB(s) galaxies may reflect the different bar growth rate which is higher in the latter case. Analysis of the instability of rotating stellar systems with highly elongated orbits was presented by Polyachenko (Let in Rus AJ 18, 1066). He derived analytically the dispersion relationship for the small perturbations in the simplest model of rotating spherical cluster with elongated orbits of stars. This approach may account for the observational evidence of similarity of bulges to oblate spheroids and the absence of clear correlation between the rate of rotation and the shape of elliptical galaxies. The theoretical and observational data give evidence that the radial orbit instability is the very cause of ellipticity of E-galaxies. In this scheme the maximal flattening of E-galaxies (c/a = 0.3) may be naturally explained by the fire-hose instability (Polyachenko Rus AJ 69, 934).

III. ACTIVE NUCLEI AND QSO's

Spectral variations of the AGN NGC 7469 (Sy 1) were observed and analyzed by Chuvaev, Lyutyi and Doroshenko (Let in Rus AJ 16, 867). Data taken from the 1983-1990 yrs observations revealed correlation between H-beta/[OIII] - ratio and U-magnitude which agrees with model of photoionization. During several months AGN

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changed its type from Sy 1 to Sy 2 and back. The results of spectral and continuum variability observations for the other Seyfert galaxy - NGC 4151 - were given by Oknyansky, Lyutyi and Chuvaev in Let in Rus AJ 17, 238. For NGC 4151 significant variations in continuum intensity and broad H-alpha line profile have been found by Sergeev (Ap Sp Sci 197, 77). An attempt to find optical brightness periodicity of 3C 273 have been fulfilled by Belokon and Babadzanyants (Rus AJ 68, 1 & 70, 243). They claimed the existence of the 307-day period for optical flares about 0.3 magnitude amplitudes and the possible 13.4 year period during the whole observational time (1887-1991 yrs). Correlations are found between these periodicities and the ejections of radiojets observed at VLBI. Afanasiev, Balega, Orlov and Vasyuk (AAp 266, 15) used high resolution speckle spectrograph to find structure of the 1"-core of NGC 1068 in the [OIII] emission line. Accurate positions and cloud velocities were obtained. Their positions appear to coincide with radiocomponents on the VLA radiomap. Artyukh and Ogannisyan are presented their results of search of compact nuclear radiosources of nearby galaxies by their interplanetary scintillation at 102 MHz. Radiosources have been discovered in 44 out of 265 galaxies, 13 of them appeared to be compact (scintillating). None of compact sources was found in E-galaxies which gives evidence that there are different physical conditions in intrinsically weak active nuclei of E and S-galaxies. Bochkarev and Nazarova (Rus AJ 68, 918) estimated typical physical parameters of AGN's and QSO's by comparing observed relative intensities of hydrogen and He II - lines with calculated ones from photoionization models for the region of formation of high-excitation lines which are located above the accretion disk surface. Electron number density, temperature and velocity gradient for these extremely inner regions were found. Theoretical model of radioemission of AGN's which emerges from the regions of formation of their narrow emission lines (about 100 pc) was developed by Zentsova and Fedorenko. Gaseous clouds producing this emission, are moving in the surrounding hot gas and induce shock waves. The latter accelerate electrons which produce radio emission via synchrotron mechanism. According to Zentsova (Rus AJ 68, 652), emission clouds, radiating the permission lines, appear in the outer regions of accretion disk as a result of it's fragmentation due to the gravitational instability and move outward by the action of strong radiation force. Vil'koviskij (Rus AJ 68, 1150) proposed self-consisted model for the formation of absorption lines of QSO in a plasma flow basing on a joint solution of plasma dynamics and line radiation transfer equations. Model spectra are well consistent with observed QSO's spectra with broad absorption lines. The model of X-ray emission of QSO's was presented by Suleymanov (AASp Trans 2, 197). He considered high luminosity accretion disks around supermassive black hole in the zone where radiation pressure is dominant. The temperature of accretion disk is found to be a function of accretion rate.

IV. SYSTEMS OF GALAXIES

Ninkovich, Chernin, and Shakenov (Let in Rus AJ 16, 1059) have proposed a set of dynamical models for the Local Group to analyze the amount of and possible spatial distribution of dark matter (DM). Comparison with observational data shows that the mass of DM is as much as 5 - 10 times of the total stellar masses of the galaxies. It gave also arguments in favor of individual DM corona of the system as a whole. A model of chemical and photometrical evolution of clusters of galaxies explaining the observations of deuterium and CNO-elements in galaxies of different types and ages as well as evolution of galactic luminosities and colour indexes was proposed by Vajner, Glukhov and Chuvenkov (Rus AJ 68, 225). A possible presence of DM in the galaxy triplets was analyzed by Anosova, Kiseleva, Orlov and Chernin (Rus AJ 69, 461). A method of stimulated catalogues was suggested in order to estimate DM. The method was applied to the 46 probably physically connected galaxy triplets from the list by Karachentsev e.a. The most probable average estimate of hidden mass is $M_o = (4.6 \pm 1.1) M_t$, where M_t is the total mass of the galaxies in triplet.

3. Catalogues and Atlases

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(S. Okamura)

This report covers the material which appeared in ApJS, ApJ, AJ, a&AS, and MNRAS during the period of mid-90 to mid-93 with several additions. I apologize for incompleteness.

1990

Lauberts+	The surface photometry catalogue of the ESO-Uppsala galaxies	ESO
Kodaira+	Photometric atlas of northern bright galaxies	Univ. Tokyo Press
Zabludoff+	The kinematics of Abell clusters	ApJS 74, 1
Ohta+	Surface photometry of barred spiral galaxies	ApJ 357, 71
Lu+	Identifying galaxies in the zone of avoidance	ApJ 357, 388
van den Bergh+	Classification of galaxies on CCD frames	ApJ 359, 4
Bushouse+	Near infrared imaging of interacting galaxies	ApJ 359, 72
Huchra+	A deep Abell cluster redshift survey	ApJ 365, 66
Cayatte+	VLA obs of HI in Virgo galaxies. I. The atlas	AJ 100, 604
Peletier+	CCD surface photometry of galaxies...	AJ 100, 1091
Seal+	...optical positions for 110 Byurakan objects...	AJ 100, 1028
Wegner+	Redshifts for fainter galaxies in CfA-I slice	AJ 100, 1405
Parker+	Galaxy redshifts with FLAIR	A&AS 84, 455
Stirpe	An atlas of Hα and Hβ profiles of AGN	A&AS 85, 1049
Gavazzi+	Near IR obs. of galaxies in Coma and Cancer	
Johansson+	...a complete sample of interacting galaxies...	A&AS 86, 167
Fouqué+	An HI survey of late-type galaxies...	A&AS 86, 473
Boyle+	A catalogue of faint, UV-excess objects	MNRAS 243, 1

1991

de Vaucouleurs+	Third reference catalogue of bright galaxies	Springer
Véron-Cetty+	A catalogue of quasars and active nuclei (5th ed.)	ESO
Dressler	The supergalactic plane redshift survey	ApJS 75, 241
Hewitt+	...optical catalog of emission-line objects	ApJS 75, 297
Kinney+	An ultraviolet atlas of quasar & blazer spectra	ApJS 75, 645
Roberts+	Interstellar matter in early-type galaxies. I...	ApJS 75, 751
da Costa+	Southern sky redshift survey: the catalog	ApJS 75, 935
Warren+	... high-redshift quasars, z>2.2. II. The catalog	ApJS 76, 23
Sparks+	Multiwavelength isophotal data for southern...	ApJS 76, 471
Stocke+	Einstein EMSS. II. The optical identifications	ApJS 76, 813
Pesche+	The Case low-dispersion northern sky survey XII..	ApJS 76, 1043
de Carvalho+	Surface photometry of..elliptical and SO galaxies	ApJS 76, 1067
Junkkarinen+	A catalog of absorption in the spectra of QSOs	ApJS 77, 203
Haynes+	HI observations of galaxies in superclusters	ApJS 77, 331
Struble+	...redshifts and velocity dispersions for clusters	ApJS 77 363
Lilly+	A deep imaging and..survey of faint galaxies	ApJ 369, 79
Iye+	A catalog of spin orientation of galaxies	ApJ 374, 112
Oegerle+	Fundamental parameters of..cluster galaxies	ApJ 375, 15
Fukugita+	The distance to the Coma cluster using...	ApJ 376, 8
Bothun+	Extremely low surface brightness galaxies in..	ApJ 376, 404
Rakos+	Narrow-band photometry..of galaxies. III...	ApJ 377, 382
Zepf+	...colors of early-type galaxies in compact groups	ApJ 383, 524
Hewett+	The large, bright QSO survey. III...	AJ 101, 1121
Gavazzi+	Multifrequency windows on spiral galaxies. I...	AJ 101, 1207
Porter+	CCD observations of Abell clusters. V...	AJ 101, 1561
Batuski+	...redshift obs. of in the Sextans-Leo region	AJ 101, 1983
Muriel+	Redshifts of southern clusters. II...	AJ 101, 1997
Weistrop+	Emission-line galaxies in the Case survey	AJ 102, 1680
Chaffee+	The large, bright QSO survey. IV...	AJ 102, 461
Morris+	The large, bright QSO survey. V...	AJ 102, 1627
Hummel+	An Effelsberg/VLA..survey of..edge-on galaxies	A&AS 87, 309

Richter+	HI obs.. of galaxies in nearby Zwicky clusters	A&AS 87, 425
Harnett+	Observations of HI galaxies at 843MHz	A&AS 88, 73
Wozniak+	Surface photometry of early-type barred galaxies	A&AS 88, 325
Cappi+	Redshifts of southern rich clusters	A&AS 88, 349
Nieto+	Isophotal shapes of early-type galaxies. I...	A&AS 88, 559
Maza+	Calar-Tololo survey. III. HII galaxies	A&AS 89, 389
Corradi+	Kinematical obs. of spiral galaxies: bibliography	A&AS 90, 121
Capelato+	...radial velocities in clusters of galaxies	A&AS 90, 355
Terlevich+	A spectrophotometric catalogue of HII galaxies	A&AS 91, 285
Paturel+	An extragalactic data base: errors & misprints	A&AS 91, 371
Wang+	Optical identification of IRAS point sources...	MNRAS 248, 112
Sutherland+	Finding charts for southern IRAS galaxies	MNRAS 248, 483
Owen+	Surface photometry of radio galaxies. II...	MNRAS 249, 164
Couch+	...catalogue of distant galaxy clusters	MNRAS 249, 606
James	An IR study of dwarf galaxies in the Virgo cluster	MNRAS 250, 544
Takase+	Kiso survey for UV-excess galaxies. XII-XIV	Publ Nat A Obs Japan 2, 7, 37, 239
Saito+	Catalogue of galaxies behind the Milky Way. I-II	Kyoto Univ.

1992

Dressler+	Spectroscopy of galaxies in distant clusters. IV.	ApJS 78, 1
Henning	A study of a 21cm-selected sample of galaxies. I.	ApJS 78, 365
Freudling+	HI obs. of galaxies in the Hercules supercluster	ApJS 79, 157
Tully+	Nearby galaxy flows modelled by the light distr.	ApJS 80, 479
Owen+	A 20cm VLA survey of Abell clusters of galaxies..	ApJS 80, 501
Fabbiano+	An X-ray catalog and atlas of galaxies	ApJS 80, 531
Schneider+	Northern dwarf & low surface brightness galaxies	ApJS 81, 5
Han+	I-band CCD surface photom. of...16 nearby clusters	ApJS 81, 35
Mathewson+	...peculiar velocities of 1355 spiral galaxies	ApJS 81, 413
Bozyan	Optical identification..of 3196 radio sources...	ApJS 82, 1
Stephenson+	The Case low-dispersion northern sky survey. XIII.	ApJS 82, 471
Edelson+	The Colorado IUE active galaxy survey. I. Blazers	ApJS 83, 1
Strauss+	A redshift survey of IRAS galaxies. VII...	ApJS 83, 29
Odewahn+	Mean galaxy luminosity classifications	ApJS 83, 65
Postman+	The distr. of nearby rich clusters of galaxies	ApJ 384, 404
Pierce+	Luminosity-line width relations and...	ApJ 387, 47
Lehnert+	Multicolor images of..around high redshift quasars	ApJ 393, 68
Fairall+	Redshift obs. in the Hydra-Centaurus region	AJ 103, 11
Visvanathan+	Redshifts of spiral galaxies...direction of the GA	AJ 103, 1057
Schombert+	A catalog of low surface brightness galaxies...	AJ 103, 1107
Visvanathan	Photom. of spiral galaxies...direction of the GA	AJ 103, 1501
Hutchings+	Optical imaging of QSOs with 0.5 arcsec resolution	AJ 104, 1
Thuan+	The far-IR properties of CfA galaxy sample. I...	A&AS 92, 749
Fouqué+	Groups of galaxies within 80 Mpc. II...	A&AS 93, 211
Prieto+	Multiband..surface brightness distr. of spirals...	A&AS 93, 557
Amram+	Hα velocity fields and rot. curves of cluster gal.	A&AS 94, 175
Scodeggio+	Multifrequency windows on spiral galaxies. II...	A&AS 94, 299
Trevese+	Properties of nearby clusters of galaxies. I...	A&AS 94, 327
Poulain+	Isophotal shapes of early-type galaxies. II...	A&AS 95, 129
Jörgensen+	CCD surface photometry of...galaxies in Coma	A&AS 95, 489
Garcia+	New HI obs. for some edge-on spiral galaxies	A&AS 96, 435
Green+	...active and normal gal. observed in IR & X-ray	MNRAS 254, 30
Lumsden+	Edinburgh-Durham...catalog IV. Cluster catalog	MNRAS 258, 1
Takase+	Kiso survey for UV-excess galaxies. XV-XVI	Publ Nat A Obs Japan 2 399, 573

1993

Nolthenius	A revised catalog of CfA1 galaxy groups in...	ApJS 85, 1
Ciliegi+	A catalog of X-ray spectra of BL Lac objects	ApJS 85, 111

Hamabe	Surface photometry of Hydra I cluster of galaxies	ApJS 85, 249
Kinney+	An atlas of UV spectra of star-forming galaxies	ApJS 86, 5
Price+	VLA observations of 91 quasars at 0.35<z<1	ApJS 86, 365
Owen+	A 20cm VLA survey of Abell clusters of galaxies...	ApJS 87, 135
Hewitt+	A revised and updated catalog of QSOs	ApJS 87, 451
Zucca+	All-sky catalogs of superclusters of Abell-ACO...	ApJ 407, 470
Scodeggio+	21 cm study of spiral galaxies in clusters III...	ApJ 409, 110
Lilly	A deep I-band selected galaxy sample	ApJ 411, 501
Wegnert+	A survey of the Pisces-Perseus supercluster V...	AJ 105, 1251
Giovanelli+	A survey of the Pisces-Perseus supercluster VI...	AJ 105, 1271
Huchra+	The Morphological Cat. of Gal. equatorial survey	AJ 105, 1637
Rice	An atlas of high-resolution IRAS maps of..galaxies	AJ 105, 67
Vogel+	Emission-line galaxies in Hamburg quasar survey	A&AS 98, 193
Binggeli+	Dwarf galaxies in the Virgo cluster. II...	A&AS 98, 297
Klaas+	Identification..of..extragalactic IRAS sources	A&AS 99, 71
Reshetnikov+	A photometric study of interacting galaxies. I..	A&AS 99, 257
Garilli+	Galaxy velocities in eight southern clusters	A&AS 100, 33
Colless+	Photoelectric & CCD photom. of E & SO galaxies	MNRAS 262, 475

4. Galaxy Clustering

(J. Huchra)

As our ability to observe the universe grows, so does both our knowledge of the properties of individual groups, clusters and superclusters of galaxies and our knowledge of the general pattern of the distribution of galaxies in space. Often this increase of knowledge does not bring with it a concomitant increase in understanding. Sometimes we astronomers get lucky. I will divide this report into three sections, one on groups and clusters, one on large-scale structure and one on large-scale velocity fields.

I. GROUPS AND CLUSTERS

The launch of ROSAT, the construction of large galaxy redshift databases, and the development of multiobject spectrographs all have had very large impacts on the study of groups and clusters over the last three years. ASCA is also just beginning to provide high quality x-ray data on clusters. Significant advances have been made in the determination of the cluster temperature function from x-ray data (e.g. Henry & Arnaud; Edge & Stewart) and the cluster velocity dispersion function from optical redshift surveys in clusters (e.g. Zabludoff +). These are just being both rectified with each other (Bahcall & Cen) and are beginning to be used in tests of cosmological simulations as proposed by Frenk + in 1990, and examined in more detail by other workers (e.g. Evrard +).

It is becoming increasingly clear that groups are low luminosity analogues of clusters — virialized systems but will smaller total masses and binding energies and thus velocity dispersions and temperatures. Ramella + have described the connection between groups and large-scale structures by examining the properties of groups in the ''Great Wall.'' Several analyses have been done of the properties of galaxies in groups including attempts to detect intergalactic extinction in groups. There is a puzzling observation that fainter galaxies that have been assigned to groups generally have larger than average redshifts. This is almost certainly a selection/interloper effect. Determinations of the mass-to-light ratios of groups still arrive at relatively small values (a few hundred in solar units with H_0 = 100 km/s/Mpc), which correspond to values of Ω of 0.1-0.2. The most exciting observations of groups over the last few years has been the detection of significant cool (≈ 1 kev) x-ray gas in many loose and compact groups (Mulchaey +; Ponman & Bertram; Mushotzky +; Ebeling +; Bohringer +). While the exact source of the gas is uncertain in any individual group (general potential versus individual galaxies), it is clear that many, if not all such objects are dynamically relaxed and belong at the low mass end of the continuum of galaxy clustering. Improved group catalogs have been constructed from homogeneous galaxy redshift surveys by Ramella +, Nolthenius, and others.

Work has also continued on two smaller but important fields in cluster research. Fabian +, Canizares + and others continue observations both in the x-ray and optical of cooling flows. There are indications from optical and IR photometry that low mass stars are forming in cooling flows, and HST observations of NGC1275 (Holtzman +) have revealed the existence of what appear to be young globular clusters. The study of gravitational lensing byclusters, pioneered by T. Tyson after the initial discoveries of arcs by Lynds and Petrosian, has become a major industry for the determination of cluster potentials and masses. Noteworthy work in this field has come particularly from the French group of LeFevre, Mellier, Soucail, Fort and collaborators.

Lastly, although severely hampered by the presence of spherical aberration, the HST observations of distant clusters by Dressler, Oemler, Gunn and Butcher are noteworthy for providing measures of the evolution of cluster galaxies and the probable resolution of the Butcher–Oemler effect.

ROSAT and redshift surveys have also improved our understanding of substructure in galaxy clusters (e.g. Forman & Jones; Fabricant +; Beers +; Zabludoff & Franx). Most clusters, even rich clusters like Coma, exhibit some substructure both in the optical galaxy distribution and in x-ray maps. Current estimates agree with the earlier estimates of Dressler and of Geller and Beers that 30–50% of all "rich" clusters are not completely dynamically relaxed. The actual fraction may be even higher.

II. LARGE-SCALE STRUCTURE

Observations of large-scale structure continue to be driven by the several major galaxy and cluster redshift surveys described in the section on Galaxy Redshifts. This three year period has seen the completion of several large surveys such as the IRAS QDOT survey (Saunders +) and 1.2 Jy Survey (Strauss +), the continuation of the CfA survey (Huchra & Geller) and the "Brick" survey of Kirshner +, and multiple analyses of same. There is now general agreement that the galaxy clustering distribution exhibits significant power on large scales (e.g. Vogeley +; Efstathiou +; Peacock, Fisher +). Discrepancies between the results from studies of infrared bright galaxies (IRAS selected) and optically selected galaxies may be the result of biases in the surveys or real differences in the clustering properties of early versus late type galaxies. This author favors the latter interpretation. In any case, the differences between the data sets are small compared to the difficulties of fitting proposed models of structure formation to the observations. When simulations are normalized at small scales, they fail to predict the observed large scale clustering by many model "sigma." Fits can only be obtained by introducing extra parameters, such as a scale dependent biasing parameter for galaxy formation. The importance of the initial results on periodicity in the pencil beam survey of Broadhurst + continues to be debated.

Observations of the clustering of clusters also contribute to the mismatch of theory and observation. Although there still is a debate about the exact correlation length of the cluster–cluster correlation function (e.g. Postman +; Efstathiou +, Plionis +, Scaramella +), which continues even when x-ray selected samples of clusters are studied (e.g. Nichol & Collins + versus Henry & Briel), independent of whether the scale length is 14 or 20 Mpc, there is still difficulty in fitting Cold Dark Matter simulations simultaneously to the small-scale galaxy and clustering and the clustering of clusters. Perhaps the best solutions to the above observational problem are offered by the ROSAT All Sky Survey of Hasinger,

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Böhringer and Trümper, who, in collaboration with groups of optical observers in the northern and southern hemisphere, are systematically identifying clusters in the x-ray. These samples will provide deeper and more consistent cluster catalogs than have previously been available.

III. LARGE-SCALE VELOCITY FIELDS

Since the discovery (or, more correctly, the rediscovery and measurement) of the infall of the Local Group into the Virgo cluster and the rebirth of interest in the Rubin-Ford effect caused by the discovery of a possible Great Attractor in Hydra-Centuarus, less than a decade ago, there has been enormous interest in the measurement of large-scale flows in the nearby universe. The two major cosmological problems addresses by this work are (a) the attempt to discover the cause (gravitational) of the microwave background dipole anisotropy, which is usually attributed to a motion of the Local Group w.r.t. the cosmic reference frame, and (b) the use of the flow field with the local galaxy density field to determine Ω.

Several major efforts to measure the flow field have been completed in the last few years. For individual galaxies, Mathewson, Ford and Buchhorn have completed a survey of spirals over a large area in the direction of the GA, while Dressler and Faber and coworkers have surveyed a smaller area. Both groups were looking for signatures of the backside infall into the GA mass concentration. They disagree on their results, with Matthewson + failing to find convincing evidence for a spherical flow field, while Dressler and Faber, looking deeper over a much smaller field claim to see the infall. Willick and Courteau have completed detailed studies of the flow field as doctoral thesis projects; Willick examining the Perseus-Pisces region and Courteau working on a whole sky sample. Bertschinger and Dekel and collaborators have attempted to match the potential field as measured by the gradients in the galaxy flow field (from data assembled by Burstein and others) with the galaxy density field from the IRAS 1.936 Jy survey. Kaiser + have done similar analyses for the QDOT survey. Generally, the IRAS galaxy versus flow field results yield high values for Ω, near unity. Attempts to do the same for the optical surveys (e.g. Lahav & Scharf; Hudson) arrive at much lower values of Ω (0.3-0.5).

On larger scales, over the last few years there has been considerable debate as to the cause of the microwave background dipole, with a large group of astronomers favoring the Great Attractor hypothesis (that most of the 630 km/sec measured by COBE is developed locally, within 8000 km/s) and another large group (e.g. Tully & Scaramella & coworkers; Raychaudhury +) arguing that the Shapley Supercluster concentration, which lies behind Hydra-Cen by about a factor of 3 in distance, but appears to be much more massive) is also a major contributor to the acceleration of the Local group. Several groups have attempted to measure the Local group velocity w.r.t. the reference frame of galaxy clusters (e.g. Mould +; Lauer & Postman). Mould + used the Tully-Fisher technique to observe nearby clusters with Parkes and Arecibo and were not able to cleanly distinguish between a GA flow or a bulk flow on larger scales. Lauer and Postman used the luminosities of first ranked cluster galaxies to measure the motion of the Local Group w.r.t. a sample of Abell clusters inside 15,000 km/s and found, that to within 2σ, the LG appears to be at rest w.r.t that frame. This would imply, if the CMB dipole is due to a motion of the LG, that their entire Abell cluster inertial frame must be participating in a bulk flow w.r.t. the CMB frame with an amplitude of nearly 700 km/s. These results on large scales are, again, extremely difficult to reconcile with the current best CDM simulations of structure formation in the universe, especially when the simulations are normalized by either the now observed very low amplitude fluctuations in the CMB on degree scales or by the clustering amplitude of galaxies on small scales.

5. Population Synthesis and Spectral Evolution
(G. Bruzual)

During the last three years there has been excellent progress in our understanding of stellar populations in nearby early type galaxies. A long standing problem, the source of the UV light in elliptical galaxies and in the central bulge of early type spirals, and in particular, the very steep UV upturn observed in the spectral energy distribution (SED) of the most luminous and metal richest ellipticals, is now closer than ever to being understood. Despite its spherical aberration HST is finally resolving stars in the central bulge of M31 (King + ApJ 397, L35) and in M32. The Hopkins Ultraviolet Telescope (HUT) also acquired a spectrum of the central bulge of M31 (Fergusson & Davidsen ApJ, in press) and of the elliptical galaxy NGC 1399 (Fergusson + ApJ 382, L69) during the Astro-1 space shuttle mission. High quality IR photometry by Freedman (AJ 104, 1349) has revealed intermediate age AGB stars in M32. HST FOS-spectra of 6 early-type weak radio galaxies with $0.08 < z < 0.53$ have been obtained by Windhorst + (ST-ECF/STScI Workshop on Science with the HST, eds. Benvenuti & Schreier). All of these galaxies show UV upturns. These results should be taken with caution, however, since a good fraction, if not all, of the detected UV light may be FOS red grating scattered light (Windhorst +).

These data have permitted that the several possible sources of the UV light comprehensively reviewed by Greggio and Renzini (ApJ 364, 35) be examined by means of highly sophisticated and complete population synthesis models (Worthey, PhD Thesis; Bruzual & Charlot ApJ 405, 538; Magris & Bruzual ApJ, in press; Bressen + ApJ, in press). This last work summarizes the results of a large theoretical effort to compute the spectro-chemical evolution of elliptical galaxies. A clearer picture seems to be emerging in which PAGB stars can be responsible of the UV flux observed in the UV-coolest galaxies, whereas higher than solar metallicity AGB-Manqué stars are the most likely source of the UV photons in the steep UV galaxies. The lack of flux below 1100 Å in the SEDs of NGC 1399 and the central bulge of M31 has been used by Fergusson + and Bressan + to argue against hot PAGB stars as the only or most important contributor to the UV in these galaxies. The cooler and longer lived high metallicity AGB-Manqué stars produce enough light in Bressan + models to account for the measured fluxes. The presence of an intermediate age population in M32 seems to be an inescapable conclusion from the detection of stars at the tip of the AGB which belong to this population (Freedman). This is corroborated by spectral synthesis results.

I. EVOLUTION OF FIELD GALAXIES

Traditionally, the steep slope of the faint field galaxy counts and their very blue colors have been explained as the result of mild evolution in the SEDs of galaxies. The excess of counts above non-evolutionary models has been claimed to be a factor of two by $B \simeq 20$ (Maddox + MNRAS 247, 1P; Loveday + ApJ 390, 338) or by $B \approx 22.5$ (Colless + MNRAS 205, 1287). The large number of blue counts has been claimed to be incompatible with a flat ($\Omega = 1$) Freidmann universe (Koo ASP Conf No. 10, 268; Guiderdoni & Rocca-Volmerange A&A 227, 362), or with the observed near-infrared K band counts (Cowie + preprint), even if galaxy evolution is included in the models. In contradiction, recent redshift surveys show that galaxies fainter than 20th mag exhibit redshift distributions close to that predicted by no evolution models (Colless +; Lilly + ApJ 369, 79). These apparently contradictory facts have led several workers to propose that dramatic revisions to the conventional view are needed. The cosmology has been revised by Fukugita + (ApJ 361, L1) by adopting a non-zero cosmological constant, Λ. The non-conservation of galaxy number due to mergers has been proposed by Cowie + (Nature 354, 460) and Broadhurst + (MNRAS 355, 55). Cowie + and Babul and Rees (MNRAS 255, 346) have assumed a disappearing population of dwarf galaxies.

The review by Koo and Kron (ARAA 30, 612) summarizes current status of observation and interpretation on the subject of faint galaxy number counts, and color and redshift distributions. These authors show that the existing data on B, R, and K galaxy counts, (B–R) colors, and redshift distributions, is consistent with a simple picture in which the cosmological constant is zero, the number of galaxies is conserved over time, and the shape of the luminosity function for each galaxy class is constant. They argue that the combined uncertainties in the models and in the data so far preclude the necessity of more exotic assumptions. A no-evolution model accounts for most of the observed trends in the data, with the exception of the excess counts at faint visible-band magnitudes, which may indicate that mild luminosity evolution occurs in these galaxies. This controversial no-evolution model has been examined in more detail by Koo + (ApJ Letters, in press), who confirm Koo and Kron contentions. The essential difference in this interpretation with respect to previous models is the relaxation of the assumption that galaxies of all color classes share the same luminosity function (determined locally) and the use of an objective technique to derive from the same faint galaxy data that is being fitted the most plausible luminosity function for each color class. The derived total luminosity function is compatible with recent determinations by Lonsdale and Chokshi (AJ 105, 1333), Loveday + and Eales (ApJ 404, 51).

II. EVOLUTION OF BRIGHTEST CLUSTER GALAXIES

The simplest experiment to detect spectral evolution in galaxies is the comparison of SEDs of distant galaxies with those of nearby galaxies whose stellar population differ only in age. Up to $z \approx 0.5$ a red envelope seems to be well established, indicating that at any $z \leq 0.5$ the reddest galaxies (mostly BCG's) are as red at rest as nearby elliptical, allowing for essentially no spectral evolution during a large fraction of the age of the universe. The fraction of blue galaxies in clusters seems to increase with z (Dressler & Gunn ASP Conf No. 10, 200; Couch + MNRAS 249, 606). The selection of distant galaxies via optical luminosities and colors may exaggerate the importance of the Butcher–Oemler effect and discriminates against the early-type cluster galaxies (Aragón-Salamanca + MNRAS 262, 764). Comparison of the SEDs of the blue cluster galaxies, some of them undergoing short-term star formation, with nearby ellipticals does not provide conclusive detection of evolution of the red envelope galaxies, since the reddest galaxies in the clusters may have not been visible in the selecting optical band. Aragón-Salamanca + circumvent this problem by selecting the cluster galaxies at near-infrared wavelengths, which sample equally well both early and late type galaxies. By studying clusters up to $z \leq 0.9$ they conclude that they have detected the spectral evolution in the galaxies defining the red envelope: by $z \approx 0.9$ there are no cluster galaxies as red at rest as present day ellipticals.

6. Working Groups on Photometry, Kinematics, and Dynamics of Galaxies
(R. Buta)

Research the past three years on the topics related to this working group has been very extensive, and I cannot hope to summarize it all here. I only draw on a few topics that indicate the flavor of what has been done. This working group is a combination of what were formerly known as the "Working Group on Galaxy Photometry and Spectrophotometry" and the "Working Group on Internal Motions in Galaxies". The merger took place in 1991.

One of the most exciting results of the last three years has been the discovery of genuine counter-rotating systems in disk galaxies. Rubin and collaborators (ApJ 394, L9) discovered co-spatial counter-rotating stellar disk in NGC 4550. Baun and collaborators (Nature 360, 442) discovered counter-rotating and probably co-planar gaseous disks in the "Black Eye" galaxy NGC 4826. Up until these findings, kinematically-distinct, counter-rotating systems had only been found in ellipticals. These results show that even normal-looking disk galaxies can possess distinct kinematic subsystems indicative of the effects of recent or even old mergers.

Evidence for supermassive black holes in galactic nuclei increased with a detailed photometric and kinematic study of the edge-on SO galaxy NGC 3115 by Kormendy and Richstone (ApJ 393, 559). They regard this object as the "best BH candidate after M31".

The discovery of declining rotation curves in some nearby galaxies (Carnigan & Puche NGC 7793, AJ 100, 394; Casertano & van Gorkom NGC 2683 & 3521, AJ 101, 1231) has been important for the study of dark haloes. These observations may signal the end of the so-called "conspiracy" between disk and halo that has been hypothesized to explain why we do not normally see, in the rotation curve, the transition region between where the disk and halo each dominate the potential.

Polar ring galaxies continued to shed important light on the shapes of dark haloes around SO galaxies. An excellent atlas of polar ring galaxies by Whitmore + (AJ 100, 1489) has established the class well. Now, individual objects are being followed-up. In the case of NGC 4650A, a dynamical model which accounts for the mass of the polar ring (previously ignored) favors a halo as flattened as E6-7 (Sackett & Sparks ApJ 361, 408). In contrast, a study of the complex dust lane pattern in NGC 4753 has been interpreted as an inclined disk strongly twisted by differential precession in a total mass distribution no more flattened than E1.6 (Steiman-Cameron + AJ 104, 1339).

Numerical simulations by Athanassoula (MNRAS 259, 345) have clarified the factors that determine the shapes of dust lanes in bars. This led to the discovery of "centered shocks", that is, shocks that would give rise to dust lanes centered along the length of a bar, rather than greatly offset as is normally seen. Some late-type barred spirals show such centered dust lanes.

CO studies have led to some interesting findings. Molecular bars in the central regions of galaxies are now being routinely found. Since the beginning of the current triennium, molecular bars have been found in NGC 5457 (Kenney + ApJ 366, 432) and NGC 2251 (Kenney + AJ 103, 784). This is in addition to features found previously in IC 342, especially interesting because the molecular bar is a small feature aligned nearly perpendicular to the primary bar. In NGC 5457, the offset is only about 25 degrees between a molecular gas bar and a weak oval. These kinds of misalignments between a stellar and a gaseous bar could signify definitive detection of the inner Lindblad resonance (ILR) in these galaxies. The last triennium also saw the highest resolution CO observations yet obtained from M51 (Garcia-Burillo + AA 274, 123), which appears to have a molecular ring located near an ILR.

The new class of giant low surface brightness (LSB) galaxies, defined by Malin 1 in 1987, received an impetus with the discovery of a second example by Bothun + (ApJ 360, 427). Since these discoveries, much effort has gone into identifying more examples and establishing their properties over a variety of wavelengths (Bothun + AJ 106, 531 + references). These objects are important as a class because they appear to be disk galaxies whose rate of evolution of gas into stars has been slow compared to more normal Hubble types. It is argued that "the distinguishing characteristic between (high surface brightness) and LSB galaxies is the net number of tidal interactions that each has experienced over a Hubble time."

Infrared detectors have advanced over the past three years to the point where it is possible to image a moderate-sized galaxy in a single frame. Block and Wainscoat (Nature 353, 48) presented blue and 2.1 micron images of the prominent grand design spiral galaxy NGC 309 and highlighted the enormous difference in appearance. They argue that a near infrared classification of galaxies is now feasible and should be a major improvement over the existing Hubble system based on blue light images.

The last triennium also provided the first definitive identification of a leading spiral arm in a galaxy, the SA(r) ab spiral NGC 4622. G. Byrd recognized in 1988 a spiral feature in the inner regions of NGC 4622 that appeared to wind opposite to the winding of two outer spiral arms. A follow-up photometric BVI study (Buta + AJ 103, 1526) confirmed the reality of the feature as a stellar density enhancement. N-body simulations (Byrd + AJ 105, 477) have successfully reproduced the structure of NGC 4622 in terms of a small, plunging retrograde companion.

A stunningly large contribution to the database of surface brightness profiles and rotation curves of spiral galaxies has been the massive work of Mathewson and collaborators (ApJS 81, 413). The data were obtained to study peculiar velocities towards the so-called Great Attractor. Completely apart from this part of the study, there are now more homogeneous rotation curves and light profiles available than ever before, and surely they will be used for other studies on the structure and dynamics of galaxies.

The use of N-body simulations for the study of the evolution of galaxies has progressed immensely. The past triennium saw the first Astrophysical Journal videotape ever produced as a regular part of an issue. The papers associated with the video are in the July 10, 1992 issue and include simulations of galaxy clustering, mergers, off-center nuclei, and narrow-angle-tail radio sources. Other noteworthy studies not on video are 3D simulations of bars (Pfenniger & Friedli AA 252, 75), gaseous rings around triaxial systems (Pearce & Thomas MNRAS 248, 688), and mergers of disk galaxies producing counter-rotating gas disks (Hernquist & Barnes Nature 354, 210).

A flurry of activity concerning the optical thickness of galaxy disks followed a study by Valentijn (Nature 346, 153). He used data for 9,400 galaxies from the ESO-LV database to deduce that spiral disks are optically thick and suggested that this invalidates the mass-to-light ratios commonly used to infer the existence of dark matter. Burstein + (Nature 353, 515) dismissed Valentijn's conclusion as unreliable based on his analysis, owing to selection effects, and argued that one needs reliable distances to circumvent the confusion caused by these effects. They nevertheless also conclude that disks are optically thick. However, direct tests of optical thickness can be made for a small number of overlapping (spiral on elliptical) pairs of galaxies. White and Keel (Nature 359, 129) and Andredakis and van der Kruit (AA 265, 396) have used two such pairs to show that, except in the regions of bright spiral arms, disks are optically thin. The controversy continues. In a related near IR study (AJ 103, 1761), Peletier and Willner suggested that galaxy disks are semi-transparent in the H-band. They also suggest that "Freeman's Law" (constancy of central surface brightness) is not an intrinsic property of true disk mass distributions.

The triaxiality of elliptical galaxies has been the subject of numerous photometric and kinematic studies. The main evidence comes from isophotal twisting and minor axis rotation. A detailed review is given by Franx (Morphological and Physical Classification of Galaxies, Longo + eds, p. 23). The same volume provides work concerning stellar and gaseous disks in ellipticals. Concerning gaseous disks, Bertola + (ApJ 373, 369) found that a triaxial model could explain the velocities within a gaseous disk in the elliptical NGC 5077 whose rotation axis is misaligned with the apparent major axis by 23 degrees. Bertola + (ApJ 374, L13) also discuss triaxiality in disk galaxies by measuring misalignments between bulge and disk major axes.

Related to early-type galaxies, Schweizer and coworkers (ApJ 364, L33; AJ 104, 1039) discuss interesting correlations found between the line strengths and colors of E and SO galaxies and the presence of fine structure in the morphology, such as ripples, plumes, boxy isophotes, shells, etc. The H-beta absorption line strength increases for ellipticals, and both ellipticals and SO's are systematically bluer, with increasing fine structure content. It is argued that these correlations are caused by mergers over at least 1/3 to 2/3 the present age of the universe.

The study of spiral structures in galaxies continues to be very active. A workshop was held at STScI that covered resonances in grand design and barred spiral galaxies (PASP 105, 638-674), and is a useful source of the most recent references. Perhaps the best identified resonance is the outer Lindblad resonance, which is obviously important in many early-type spiral galaxies (Buta & Crocker AJ 102, 1715). Other resonances are important; in grand design spirals, theoretical and observational techniques for identifying resonance locations were discussed by Elmegreen + (ApJS 79,37) and Patsis + (AA 243, 373). The origin of spiral structure is still an important problem. Byrd and Howard (AJ 103, 1089) argue that at least one third of a sample of Holmberg galaxies have tidal arms, based on a self-gravitating tidal perturbation survey.

The last triennium also saw some of the first extragalactic results from the Hubble Space Telescope. A possible black hole accretion disk was detected in the elliptical galaxy NGC 4261 (S&T 2/93), surface photometry and spectroscopy of an elliptical galaxy at z = 2.39 was reported (S&T 1/93), and an x-shaped dust pattern was discovered at the center of M51 (S&T 9/92). Most interesting was Dressler and Oemler's presentation and description of the first detailed images of cluster galaxies at redshifts of 0.4 (S&T 4/93, p. 22). The galaxies showed the familiar Hubble types of nearby galaxies, so these types were already in existence up to 4 billion years ago. Interestingly, the problem with the HST optics led to unprecedented advances in image processing and reconstruction (e.g., see King + AJ 102, 1553). Using such techniques, Lauer + (ApJ 369, L41) and Benedict + (AJ 105, 1369) presented some of the first surface photometry obtained with HST, of the SO galaxy NGC 7457 and of the nuclear ring in NGC 4314.

Finally, the proliferation of data and papers in extragalactic research, particularly in the topics of this Working Group, and the development of sophisticated automatic plate scanners, has led to some important databases and other results since 1990. Firstly, the Third Reference Catalogue of Bright Galaxies (RC3), produced by de Vancouleurs and five other collaborators over the years since the 1976 publication of the Second Reference Catalogue (RC2), was finally published in 1991. Users will notice immediately how different RC3 looks from RC2: the former is in three volumes and includes more than 23,000 galaxies while the latter is one volume and includes only 4,400 galaxies. One volume of RC3 is devoted almost entirely to references. Secondly, the scanning of the Palomar Sky Survey for a massive star/galaxy catalogue has led to new techniques for automatic discrimination of star and galaxy images (see Odewahn + AJ 103, 318). Thirdly, G. Helou and B. Madore created the very useful NASA/IPAC Extragalactic Database (NED) which has changed "the way that extragalactic research is being done around the United States and around the world" (see Helou 1992, Proc. 27th Rencontre de Moriond, p. 25).

7. Galaxy Redshifts Working Group

Just as the field of mathematics and computing has its "Grand Challenges," so does astronomy. Some of ours have been set out in the 1991 Bahcall Committee Report on the next decade of astronomy. For extragalactic astronomy and cosmology, arguably the two largest projects for this decade are the mapping of the local galaxy density field (to a redshift of ≈ 0.1) and the local galaxy velocity field. Work on these projects has already begun through large programs to obtain uniform,

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whole sky galaxy samples, redshift surveys of large complete samples, and redshift independent distance measurements. Several of these will be described below.

In addition to large-scale nearby studies, the development of multiobject spectrographs combined with a new wealth of x-ray data, most notably from ROSAT, and deep optical surveys has continued the explosion of redshift data for galaxy clusters and for deep probes of galaxy evolution and cosmology.

Since this reporter's last report three years ago, the number of galaxies with measured redshifts has gone from about 38,000 to nearly 50,000. This reporter maintains the largest collection of published and private redshifts at the Harvard-Smithsonian Center for Astrophysics (the CfA Redshift Catalogue). This catalogue is periodically distributed to and obtainable from the National Space Science Data Center (NSSDC) in the U.S. and the Strasbourg Astronomical Data Center (CDS) in Europe. A somewhat more detailed catalog of galaxy properties, The Third Reference Catalogue, has been completed by G. and A. deVaucouleurs, H. Corwin and R. Buta. These catalogs contain several "complete" sub-catalogs, including the Revised Shapley-Ames catalog (RSA), the first CfA survey (CfA1), the Southern Sky Redshift Survey (SSRS), the Nearby Galaxies Catalog, the first CfA slice (CfA2), and the IRAS 1.936 Jy Redshift Survey (Strauss + 1992).

Similarly, the number of galaxy clusters from the lists of Abell, Zwicky, Corwin, Olowin and Abell and deeper surveys (e.g., Gunn & Oke, & Sandage +) with measured redshifts is over 1500. Cluster redshift catalogs can be obtained from H. Rood (USA), H. Andernach (Brazil), T. Festisova (Russia), M. Kalinkov (Bulgaria) and J. Huchra (USA).

In the last three years, several large groups continued to work on major large-area redshift surveys. The Arecibo Survey was continued by R. Giovanelli and M. Haynes and G. Wegner, who have recently completed a 21-cm survey of the Pisces-Perseus supercluster region (AJ 105, 1251 & 1271). The Southern Sky Redshift Survey was published by L. da Costa + (ApJS 75, 935), and he and M. Geller, A. Fairall, P. Pellegrini, D. Latham, J. Menzies and others have nearly completed work on the extension of the SSRS (SSRS2) to a limiting magnitude of $B_T \approx 15.0$. The QDOT redshift survey of 1-in-6 of the IRAS galaxies brighter than 0.6 Jy at 60μ has been completed by A. Lawrence, M. Rowan-Robinson, W. Saunders, G. Efstathiou, N. Kaiser and others. Although this survey contains only ≈ 2500 galaxies and is extremely sparsely sampled, it is the deepest of the whole-sky probes available and is currently being extended to include redshifts for all galaxies brighter than 0.6 Jy. The IRAS 1.2 Jy survey has been completed by M. Strauss, J. Huchra, M. Davis, A. Yahil, K. Fisher and J. Tonry. This sample contains over 5000 galaxies.

Both the QDOT sample and 1.2 Jy sample have been analyzed in long series of papers in MN and the ApJ. Primary results include the comparison of the IRAS galaxy density field with the density field determined by inverting galaxy flow field observations (most notably using the POTENT technique of Bertschinger, Dekel & Faber), attempts to estimate Ω from both this comparison and the microwave background dipole velocity — which generally give high values, 0.8-1.0, with estimated errors that are inconsistent with determinations of Ω from optical samples (Lahav +), and the derivation of the general clustering properties of late type galaxies $\xi(r)$.

The APM-Stromlo redshift survey of J. Loveday, G. Efstathiou, B. Peterson, S. Maddox + now contains nearly 1800 galaxies to a magnitude limit of ≈ 17. This sparse survey has been used to determine the clustering properties of galaxies on very large scales.

The CfA2 sruvey was continued by J. Huchra and M. Geller +. The final CfA2 survey will contain redshifts for all galaxies brighter than 15.5 in the Zwicky catalogue above the equator, a total of approximately 18,000 galaxies including those at galactic latitudes lower than originally covered in the CfA1 survey. They currently have redshifts for over 16,000 galaxies, including 2300 galaxies in the low latitude regions covered by Zwicky and Nilson. Completed CfA2 regions include 14 complete POSS strips, 6 in the north galactic cap between +8.5° and +44.5° declination, and 8 in the south galactic cap between −2.5° and +48°. Analyses of these samples by M. Vogeley + have strongly confirmed the results that standard Cold Dark Matter cosmological simulations cannot match the observed clustering properties of galaxies, in particular the clustering power spectrum, on large and small scales simultaneously. This group, with L. daCosta and others completed a redshift survey of 860 NGC galaxies between 20^h and 5^h and −17.5° and −2.5° to connect the CfA1 survey with the SSRS survey in the south galactic cap. With J. Thorstensen and G. Wegner of Dartmouth, they are also near completion of the "Century Survey" of 2400 galaxies in a 1° wide by 100° long strip through the north galactic pole.

The Las Campanas redshift survey of S. Shectman, R. Kirshner, G. Oemler and P. Schecter now also contains over 10,000 galaxies in a long strip in the south galactic cap. This survey indicates that astronomers might have finally found the scale on which homogeneity of the galaxy distribution is setting in. In previous shallow samples, the largest structures discovered were about as large as could have been discovered given the sample dimensions. In the LC survey, despite probing to more than 30,000 km/s, the largest void sizes appear to be only in the range of 5–6000 km s^{-1}.

Three major deep redshift probes have given preliminary results on the redshift distribution and spectroscopic properties of faint galaxies. These include the pencil beam surveys of T. Broadhurst, D. Koo, A. Szalay, T. Shanks +, who have also discovered an apparent periodicity in the spacing of structures along the line of sight, the deep surveys of optically selected galaxies by R. Ellis, C. Colless and collaborators, and the optical and IR based surveys of S. Lilly, L. Cowie and J. Gardner and collaborators. There yet remains considerable confusion over the nature of the number excess of faint galaxies, but it is now at least clear that the median redshift of galaxy samples as faint as 23nd is still much less than 0.5. Further progress on this front really awaits the 8 to 10-meter telescope now under construction.

Considerable progress has been made on the measurement of velocities for galaxies in clusters. Some, such as the surveys of A. Zabludoff, M. Geller and J. Huchra, D. Batuski +, and T. Beers +, have been done the old-fashioned way of one galaxy at a time. Others, such as those of W. Oegerle, J. Hill, P. Hintzen, M. Gitchett, J. Hoessel and collaborators, and P. Gray, R. Sharples, D. Carter, P. Teague and J. Lucey have used modern multifiber spectrographs on telescopes ranging from the U. of A. 90-inch to the AAT Velocity distributions in clusters are now considered not only important in the determination of the cluster masses and dynamical temperatures for comparison to X-ray observations, but are also useful in testing the small scale and deep potential properties of galaxy clustering simulations (e.g. Frenk + ApJ 351, 10).

In the near term, two major new projects that are about to get underway deserve mention. The first is the Sloan Digital Sky Survey, a project to produce a deep multicolor map of approximately 1 steradian followed by a redshift survey of 1 million galaxies in that region. The major goal of this program is to nail down, once and for all, the statistics of galaxy clustering such as the n-point correlation function, the topology of clustering and the power spectrum. The second is the Two Micron All Sky Survey, or 2MASS, which, in addition to providing fundamental information about the galaxy and stellar populations in the galaxy, will also provide a nearly whole sky map of the galaxy distribution selected at wavelengths minimally affected by extinction (i.e. the B and R bands) and dominated

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by normal as opposed to starburst galaxies (i.e. the IRAS surveys).

In closing, I would like to once again stress to all astronomers and Journal Editors the need to publish heliocentric velocities (cz) or redshifts (as $z = \Delta\lambda/\lambda$ in the optical convention), and also to publish accurate positions for the galaxies they observe. This policy was adopted by the members of the Working Group on Galaxy Radial Velocities present at our meeting during the 1988 IAU General Assembly. The publication of finding charts for confused fields is also good form. Authors wishing their data to be included rapidly in electronic databases for galaxy redshifts should send electronic versions of their tables and the correct reference to use to huchra@cfa.harvard.edu.

8. Magellanic Cloud Working Group
(N. Walborn)

Good overviews of recent Magellanic Cloud work may be found in the proceedings of a workshop at Heidelberg, "New Aspects of MC Research" (ed. Baschek + Springer 1993 = B93) and in IAU Symp. 148. Also, a review is presented by Westerlund in A&AR 2, 29, 1990. The best current Cepheid distance modulus of the LMC is 18.55 +/- 0.10 (Feast in B93). The distance modulus from SN 1987A is 18.50 with an uncertainty probably in excess of 0.13 (Panagia + ApJ 380, L23; Dwek & Felten ApJ 387, 551). Combining these distances with Walker's apparent magnitudes of MC RR Lyraes (ApJ 390, L81) significantly increases distances based on RR Lyraes and decreases the ages of galactic globular clusters. Reviews of specific areas of MC work are given by Frogel (Neugebauer Symposium, ASP in press) and Feast (Obs., in press).

Recent work on the chemical abundances of young objects in the MC confirms earlier work (a deficiency of about -0.2 dex (LMC) and -0.6 dex (SMC)), though the element ratios are non-solar (Russell & Dopita ApJ 384, 508). Adopting a higher reddening than previously for the young SMC cluster NGC 330 removes the discrepant abundances previously found (Bessell IAU Symp. 148 & Caloi + A&A 271, 109). Plez + (ApJ, in press) find a metallicity of -0.5 dex for bright SMC AGB stars.

There is much recent work on the structure and dynamics of the MC. Following earlier work which showed a large depth for old objects in the outer parts of the SMC, Hatzidimitriou + (MN 261, 873) have shown that there is a good correlation between velocity and line-of-sight distance for these stars. An interesting development is the discovery of carbon stars between the two Clouds (Demers + MN 260, 103). Westerlund + (A&AS 91, 425 & 97, 603; A&A 260, L4) find carbon stars in the SMC as faint as $M_{bol} = -1.7$. It is still not certain whether the LMC has a kinematic (i.e. non-rotating) halo of old objects. The very old clusters are too few to give an unambiguous answer (cf. Schommer + AJ 103, 447). The CH stars, previously thought to be very old and to rule out a halo, are in fact probably the most massive carbon stars in the LMC and are probably merged binaries of intermediate age or else young objects (Feast & Whitelock MN 259, 6; see also Suntzeff + PASP 105, 350). Other studies are of young stars between the Clouds (Irwin + AJ 99, 191; Grondin + AJ 103, 1234); kinematics of PN in outer LMC fields (Vassiliadis + ApJ 394, 489); and a major study of LMC structure and kinematics in H I (Luks & Rohlfs A&A 263, 41). Contrasting models of the Magellanic orbit and stream have been proposed (Shuter ApJ 386, 101; Liu A&A 257, 505; Lin, BAAS 25, 783). Fujimoto and Noguchi (PASJ 42, 505) have developed an interesting theory to explain the formation of massive young clusters in the LMC by collision between high-velocity clouds produced by LMC/SMC interactions.

Amongst other important MC results obtained recently are the discovery of OH/IR stars (Wood + ApJ 397, 552) and a methanol maser (Sinclair + MN 256, 33P); PN images from HST (Blades + ApJ 398, L41); the absence of LMC Beta Cepheid stars as evidence of a metallicity-related pulsation mechanism (Balona MN 260, 795); the

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detection of gamma-rays from the LMC (Sreekumar + ApJ 400, L67); and the MC as a possible source of gamma-ray bursters (Fabian & Podsiadlowski MN 263, 49).

Massive, hot stars in the Magellanic Clouds may be subdivided into the object-type categories of OB stars, Luminous Blue Variables and related objects, and Wolf-Rayet stars. Interest in the 30 Doradus region warrants a category of its own. Space does not permit listing the many discoveries and studies of individual interesting objects, so only major investigations of the categories or very detailed analyses of special objects are included. For the same reason, it will have to be assumed that massive X-ray binaries and SN 1987A are covered elsewhere.

Some of the most significant results concerning the OB stars were the detection of new structures in their composite HR diagram by Fitzpatrick and Garmany (ApJ 363, 119), widespread CNO anomalies in B-supergiant spectra by Fitzpatrick and Bohannan (PASP 103, 1123; ApJ 404, 734), and evolutionary interpretations of these effects by Langer (A&A 252, 669) or alternatively in terms of binary evolution by Ray and Rathnasree (MN 250, 453; ApJ 410, L99 & 411, 848). Advances in the study of O-type stellar winds and physical parameters were reported by Kudritzki + at a Workshop on HST results in Sardinia during 1992 (p. 279) and by Patriarchi and Perinotto from IUE data (A&A 258, 285). New abundance analyses of B supergiants were presented by Lennon + (A&A 234, 109) and Dufton + (ApJ 362, L59). Extensive studies of OB associations other than 30 Dor were done by Greve (A&AS 85, 895), Lortet (A&A 94, 359) and Parker + (AJ 103, 1205; ApJ 399, L87). Luminous O "stars" were resolved into multiple components by Heydari-Malayeri and Hutsemekers (A&A 243, 401 & 244, 64). Grebel (A&A 254, L5) found a large number of Be stars in NGC 330/SMC while Balona investigated variability of cluster B stars (MN 256, 425; 260, 782 & 795). Useful studies of early-type eclipsing binaries were presented by Jensen + (MN 250, 119; 254, 419 & 258, 527; 260, 777).

Only a few of the numerous studies of LBVs and related objects can be highlighted here. Wolf and Stahl (A&A 235, 340) detected inverse P Cyg profiles in the prototype S Dor. N82/LMC was found to be a very unusual Ofp object with strong carbon as well as nitrogen lines by Heydari-Malayeri + and Moffat (A&A 236, L21; 244, L9; 258, L13). A detailed spectral analysis of the Ofp/WN9 object R84 was presented by Schmutz + (ApJ 372, 664). Further observations or R127, currently in outburst, were made by Schulte-Ladbeck + and Clampin + (ApJ 407, 723 & 410, L35.)

Several systematic investigations of WR stars in the LMC were completed L. F. Smith + (ApJ 348, 471 & A&A 241, 77) studied the systematics of WC spectra and evolution, while Moffat (ApJ 348, 232) and Morris + (ApJ 412, 324) presented comprehensive results on WR colors, luminosities, and energy distributions. Koesterke + (A&A 248, 166) analyzed a number of WN spectra. Seggewiss + (A&AS 89, 105) and Walborn + (ApJ 393, L14) discussed HST spectroscopy of Melnick 42 and R136 in 30 Dor, while Hutchings + (ApJ 410, 803) did the same for R31. New WR objects were discovered by Morgan and Good (MN 243, 459 & 251, 51P) and by Testor and Schild (A&A 240, 299).

Significant advances in knowledge of the 30 Doradus complex were derived from new UV, optical and IR instrumental capabilities. HST images of R136 were presented by Weigelt + (ApJ 378, L21) and Campbell + (AJ 104, 1721), while improved ground-based interferometric observations of the object were made by Pehlemann + (A&A 256, 701). Extensive UV photometry of the region was performed with UIT by Cheng + and Hill + (ApJ 395, L29 & 413, 604). IR imaging by Hyland + (MN 257, 391) and Rubio + (A&A 261, L29) revealed a new stellar generation in 30 Dor and strongly suggests sequential star formation there. More traditional techniques also provided interesting results concerning star formation (Lortet & Testor, A&AS 89, 185), the stellar content of the surrounding associations (Schild & Testor A&AS 92, 729), and the IMF of the central cluster (Parker AJ 106, 560).

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New discovery lists for planetary nebulae are given by Morgan and Good (A&AS 92, 571) and spectrophotometry of many PN is given by Meatheringham and Dopita (ApJ 75, 407 & 76, 1085) and Vassiliadis + (ApJS 83, 87). Dopita and Meatheringham (ApJ 367, 115 & 377, 480) have modelled the emission from PN in order to derive abundances and place the central stars in the HR diagram.

Abundance analyses of normal stars have been carried out by Spite and Spite (A&A 234, 67), Luck & Lambert (ApJS 79, 303), and Thevenin and Jasniewicz (A&A 266, 85), yielding [Fe/H] ~ −0.6 and −0.3 for young stars in the SMC and LMC respectively. Olszewski + (AJ 101, 515) give abundances for a large number of clusters and Kontizas + (A&A 269, 107) show that the abundance is spatially constant for radial distances from the LMC center less than 8 kpc but that the abundance decreases at larger radii. Smith and Lambert, (ApJ 361, L69) and Brett (MN 249, 538) have investigated Li and CNO abundances in upper AGB stars and suggested the abundance patterns observed in these stars result from hot-bottom burning.

The star formation history of the LMC has been analyzed in detail by Bertelli + (ApJ. 388, 400) who conclude that there was little star formation until the onset of a prolonged burst ~ 4 x 10^9 years ago, perhaps continuing until the present time. Star cluster formation in the LMC bar is discussed by Bica + (AJ 103, 1859). In the outer SMC, Gardiner and Hatzidimitriou (MN 257, 195) find 7% of the stars belong to a 1.5 x 10^{10} yr old population, while most stars have ages of ~ 10^{10} yr. Stars younger than 2 x 10^9 yr lie preferentially on the eastern (LMC) side of the SMC. Further searches for C stars in the Clouds have been carried out by Blanco and McCarthy (AJ 100, 674) and Rebeirot + (A&AS 97, 603

Kinematics of various populations have been studied. The oldest populations (age > 10^{10} yr) are the old LPVs (Hughes + AJ 101, 1304) and the old clusters (Schommer + AJ 103, 447) which seem to lie in a thick disk/flattened spheroid with velocity dispersion ~ 35 km/s. The intermediate age populations (planetary nebulae, clusters, LPVs, and CH stars all belong to a single rotating disk with a velocity dispersion of ~ 25 km/s. Kinematic models yield a total LMC mass in the range 0.5–2.5 x 10^{10} $M_\odot$.

Studies of AGB stars have been made by Frogel and Blanco (ApJ 365, 168,; LMC bar-west) and Reid and Mould (ApJ 360, 490; SMC). Reid (ApJ 382, 143) has obtained JHK photometry of a sample of dust-enshrouded IRAS sources while Wood + (ApJ 397, 552) monitored a sample of IRAS sources in JHKL to derive pulsation periods, and showed that some of them have OH maser emission characteristic of OH/IR stars.

Kinman + (PASP 103, 1279) have found new field RR Lyraes in the outer LMC and have estimated that the LMC has a stellar halo containing ~ 2% of its mass. Smith + (AJ 104, 1430) have discovered 133 new RR Lyraes and Cepheids in the SMC and find that the former are not concentrated to the SMC bar.

Searches for and monitoring of variable stars in clusters has been carried out by a number of groups. RR Lyraes have been found in old clusters by Hazen and Nemec (AJ 104, 11) and Walker (AJ 104, 1395 & 105, 527). Welch + (AJ 101, 490 & 105, 146), have obtained CCD photometry of Cepheids in the clusters NHC 1866 and 2164. The latter study also showed that objects previously described as "superluminous giants" are actually composite images. Chiosi + (ApJ 385, 205) and Bertelli + (ApJ 412, 160) have used the cluster Cepheids to discuss the LMC distance and the Cepheid mass discrepancy.

Two major absorption-line studies of the interstellar medium were completed. Wayte (ApJ 355, 473) presented surveys of both the LMC and SMC and correlated line strengths with polarization; he arrived at a depth distribution for gas and dust. Vladilo + (A&A 274, 37) completed a depth study of the gas in the field of 30 Dor and SN 1987A; they find various gas components and indicate that the lower velocity gas is rather behind most of the stars of the study.

Measurements of the CO radio emission are being continued with the SEST in both the LMC and the SMC (see contributions by Booth & Rubio, respectively, to the 1992 Heidelberg conference, pp. 26 and 36; A&A 271, 1 & 9). Radio-continuum studies of the LMC were completed by Haynes + (A&A 252, 475) and Xu + (A&A 257, 47), which include a correlation study of the radio and the far-IR fluxes. These and other data from many wavelength domains are available in digital form from Klein (MPIfR, Bonn). A CCD-based H-alpha survey of the SMC is in progress (le Coarer, 1992 Heidelberg conference, p. 77).

X-ray data on the LMC and SMC (Einstein) have been reinvestigated and overall studies were presented (Wang +, ApJ 374, 475 & ApJS 78, 391); it is clear that higher sensitivity data and better spatial resolution are needed in X-ray observations. Some H II regions show soft X-rays explained as due to asymmetrically placed supernova explosions (Chu & Mac Low ApJ 365, 510). The ROSAT produced its first measurements of the diffuse emission of the LMC and in particular the area of the supershell LMC4 appears to show an enhancement of soft X-ray emission, giving proof of hot gas inside the cavity (Bomans + preprint).

9. Supernova Working Group
(V. Trimble)

I. DISCOVERIES AND RATES

The triennium saw 170 SNe (1990R to 1993T) announced in the IAU Circulars. Of these 73 were Ia, 13 Ib/Ic, 5 I, 56 II, and 23 received no reported spectral type. Leading discoverers were Meuller (POSS II) and Antezana (CTIO Curtis Schmidt) with 35 each, followed by Pollas (CERGA) with 29, McNaught (UK Schmidt) with 27, Wischnjewski (CTIO) 11, the Berkeley APT projects with 9, Evans (visual) with 5, Gonzalez (CTIO) 2, Hartley (UK Schmidt) 1, and single discoveries made by 16 other individuals, projects, or observatories. An additional 29 archival events turned up, mostly on POSS I plates. And we lost two: 1950E turns out to have been a minor planet (PASJ 42, 597) and 1986J a luminous blue variable (AJ 101, 1275).

The corresponding SN rate, per unit galaxy luminosity and as a function of SN type and galaxy type, remains under vigorous discussion. Since the last major review of the subject (ARA&A 29, 363), the Asiago and Sternberg searches (A&A 273, 383) have reported 0.20 events/century/10^{10} $L^B_\odot$ in E galaxies (all type Ia), and for late spirals, 0.69 Ia, 0.48 Ib/c, and 2.63 II, leading to a prediction of 1.7 ± 0.9 events per century in the Milky Way. The Berkeley automated search (ApJ 384, L9) has found SNe only in late spirals, with rates 0.4 for Ia, 1.6 for Ic, and 1.1 for type II, and predicts at least 3.3 events/century in the Milky Way. Seyfert galaxies are the same as others of the same Hubble type (A&A 239, 63), and the expected high SN rate in starburst galaxies remains elusive (AJ 102, 875 & Nat. 350, 130). Disagreement about the importance for correcting for sin i of the parent galaxy contributes to discordance in the gradient of rates from early to late spirals (A&A 234, 84; ApJ 359, 277; PASP 102, 1318; AJ 101, 845; ApJ 384, L9). Within the Milky Way, the pulsar birthrate is near 4/century (MNRAS 245, 514), and the SNR birthrate in M31 is 1.25/century (A&AS 98, 327). Galaxies with several supernovae continue to proliferate (A&A 234, 84), records now belonging to M83 with six (23A, 45B, 50B, 57D, 68L, 83N), and a galaxy with two simultaneous Ia's (1992R, 1992ac, IAUC 5543).

The SN 1987A industry wound gradually down, with only about 150 papers in the major archival journals and a timely major review (ARA&A 31, 175). The radio emission turned back on (IAUC 5086 and 5088) and the gamma-ray driven X-ray emission turned off (IAUC 5112). Visible light continues! Early plates have been recalibrated (AJ 105, 1886 & 1892; A&A 256, 447) and the Ni^{56} model generally accepted (Sov Astron Lett 18, 1). But the leveling remains a mystery. Once good photometry from ground became impossible (MN 262, 313), FOC data continued to show fading with about the time scale expected for Co^{57} (ApJ 403, 736), but the absolute amount needed (AJ 102, 1118; ApJ 384, L33 & 389, L21) is larger than that expected from models (ApJ 368, L31) or revealed by IR and gamma ray spectroscopy (ApJ 399, L137; MN 261, 522; ApJ 407, L25; Sov Astr Lett 16, 171). Since the Co^{56} contribution turned off on schedule (ApJ 357, 638; ApJ 408, 277), one is left with Ti^{44}, a pulsar, or neutron star accretion as excess luminosity sources (A&A 243, L13, 273, 155 & 253, 459). Two putative pulsars have come and gone (Nature 349, 747 & 347, 534) and the absence of evidence for a neutron star remains puzzling (ApJ 376, 234; A&A 237, L9). Evolution of the progenitor has converged on a star of 15-20 $M_\odot$ that shed first a slow, dense wind, then a fast, tenuous one, enriched in N and He, as was the residual envelope, after making a loop back to the blue, as many LMC stars seem to have done (ApJ 383, 295; A&A 243, 155; ApJ 380, 575; ApJ 363, 255; A&A 245, 182 & 593). There is some evidence that it was rotating (ApJ 358, L9) and may once have been part of a binary system (PASP 104, 717; A&A 260, 273). Interaction between the two winds and other circumstellar material account for the complex morphology within about 1pc of the SN (MN 261, 391; ApJ 405, 337; A&A 262, L9; Nature 350, 683). When the ejecta hits the wind material, fireworks at radio IR, X-ray and other wavelengths are expected (ASS 190, 1; Nature 355, 147 & 617; ApJ 379, 659) at some time between early 1993 (probably wrong) and 2002. Some three dozen papers address various aspects of the efficient mixing and clumpiness of the ejecta at early and late phases, but no perfect fit to the spectra is possible even making use of this freedom (PASP 103, 787). The formation of dust that began after about a year (MN 261, 522) ceased after another year (A&A 249, 474). Iron whiskers have been claimed (A&SS 200, 97). Two geometrical methods lead to distances of 51.2 and 52.3 kpc (ApJ 380, L23; A&A 249, 36). And efforts continued to produce a second neutrino burst (Soc Astr 35, 42; Sov Astr Lett 18, 79; A&A 271, 187). Derived limits on neutrino physics were slightly relaxed from early claims (PRL 67, 2605; A&A 254, 121).

SN 1993J has become the event to watch over the next triennium. An authentic amateur discovery (IAUC 5731), it was quickly confirmed, typed (II), and seen by IUE (IAUC 5731-38). The progenitor has probably been identified (IAUC 5736, 5741), it has become the third X-ray SN (IAUC 5748), and a rapidly evoluving radio source (IAUC 5751 ff). The optical light curve is double peaked, with significant resemblances to that of SN 1987A, including evidence for a comparable amount of Ni^{56}, but also interesting differences. Models are in the preprint stage, but close binaries with mass transfer seem to be the winning strategy. That two such interesting SNe should have gone off just a couple of months before IAU commission reports have to be written is probably not causal, but watch out for spring 1996 and 1999.

Type Ia supernovae present essentially the same three problems they did last time around: what are the progenitors, what is the explosion like, and are they standard candles useful for cosmology? Cases have been made for symbiotic stars (ApJ 407, L81) or symbiotic novae (ApJ 397, L87) as progenitors. The difficulty is that H blown off the RG donor will pollute the SN spectrum (ApJ 388, 665). WD accretors that burn the H steadily present the same problem (ApJ 370, 324). Double degenerates remain the most attractive model (ApJ 366, 198). Current catalogues include some wide pairs (AJ 361, 196), but none both massive enough to explode and of small enough separation to merge in a Hubble time (ApJ 374, 281). Doubts have even been cast on the double degenerate nature of the AM CVn (low mass) pairs (ApJ 384, 220). Explosion of white dwarfs accreting helium remains in accord with the observations, but explosion may not actually occur (ApJ 371, 317; A Zh 36, 401). The possible explosion mechanisms are supersonic detonation, which does not leave necessary intermediate mass elements (A&A 254, 177), subsonic deflagration, which does not make the right line profiles and such (ApJ 371, L23), double detonation,

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with helium igniting first, which may fit 1991T (ApJ 384, L15) and perhaps others (ApJ 370, 272), and deflagration turning into detonation, called delayed detonation. The triennium has been marked by increased enthusiasm for this last (A&A 245, 114, 246, 383, 248, L7, 253, L9; ApJ 393, L55 & 397, 304, 386, L13). The enemy of all these processes is accretion-induced collapse (ApJ 396, 649; A&A 272, 446). The precise contributions of Ia's to galactic chemical evolution are still under discussion (APA 257, 534 & 270, 288; PASP 105, 444). On the issue of whether SN Ia can be used as standard candles for cosmology, there remain some resolute supporters of an unqualified "yes" answer (A&A 236, 9, 259, 63, 269, 104; AJ 101, 1281 & 104, 696), and also some equally firm "no's" (A&AS 89, 537; AJ 103, 6632 & 104, 1156). But the eruption of 1991 bg, which was unquestionably fainter than other Virgo Ia's and also peculiar in light curve and spectral development (AJ 104, 1542 & 105, 301), has led to some enthusiasm for the idea that they are not all the same brightness, but due regard to reddening (ApJ 401, 49 & 405, L5) nature of the parent galaxy (AJ 100, 530 & 102, 236; ApJ 390, 34), and the details of light curves and spectra (ApJ 387, L33, 384, L15, 362, 235, 400, 127; AJ 104, 1541, 105, 223 & 301) allow you to separate out subclasses that can function as standard candles.

Type Ib and Ic supernovae have become well established as classes distinct from the classical Ia's. They are fainter (AJ 100, 530), presumably because they make less Fe^{56} and occur mostly or wholly among Pop I stars (AJ 103, 1788), though not necessarily in spiral arms the way SN IIs do (PASP 102, 898). They are radio sources, though different from SN IIs (ApJ 409, 162). Many modelers have converged on progenitors initially of 12-18 $M_\odot$, stripped down to helium cores of 3-6 $M_\odot$, often in close binary systems (A Zh Lett 18, 242, MN 255, 267; ApJ 361, L23; 368, L27; 366, 198; AJ 100, 1575), though the Ic could be either the high or low mass end of the sequence (AJ 100, 1575; MN 255, 267). Reasonably successful models of light curves and spectra require both early mixing (like 1987A) and late retention of the Ni^{56} decay products (ApJ 368, L27 & 308; 379, L13), though no single choice of ejected mass and explosion energy seems to fit all phases (ApJ 409, 417).

Type II supernovae sit very much where they have for the last several reports. The progenitors are massive stars, though there remains some disagreement about the exact range (AA&A 261, 433; MN 250, 786) and whether the L-type light curves go with the largest (ApJ 389, L17) or smallest (ApJ 374, 266) masses. Some surely come from binaries (ApJ 391, 246), and most have shed significant wind material before the explosion, as revealed by radio and X-ray emission from collisions by the ejecta and reprocessing of the initial uv break-out flux (ApJ 398, 248 & L 107; A Zh 36, 63 & 164). AG Car, a potential progenitor, has looped back to the blue, based on its wind properties (A&A 269, 330). The Type II's are definitely not standard candles (A&AS 98, 443; AJ 100, 530), though the majority eject about 0.07 $M_\odot$ of Ni^{56} and roughly track the light curve of 1987A after several months (AJ 100, 771 & 105, 2237). It is generally agreed that mixing of the ejecta is important generically as well as in 1987A (ApJ 390, 230). The only trouble is that the models do not actually eject anything. Shocks stall, and this is a real, physical phenomenon, not the result of numerical viscosity, a slightly wrong equation of state, etc. (ApJ 364, L22 & 376, 678; A&AS 90, 283; A&A 268, 360). Improvements in the standard model may prove to be relevant, but so far only the infall phase has been followed (ApJ 410, 740). Some more desperate measures include rapid core rotation or strong magnetic field (A Zh Lett 18, 194; A Zh 34, 163), modified neutrino physics (ApJ 398, 190 & 389, 513; Ap Lett & Comm 28, 271), and dynamical instabilities or other two-dimensional processes (Sci 258, 430; ApJ 395, 642). The situation, like the total absence of observed progenitors for SN Ia events, remains profoundly unsatisfactory.

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