28. GALAXIES

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The volume of work published on extragalactic astronomy in the period August 1966 – July 1969 has been large. Limitations of space have precluded the writing of an all-inclusive report; in all sections some selection has had to be made. References are given, whenever possible, by the reference numbers of the Bulletin Signalétique of the CNRS of France, with the omission of the Section number: "2" for vols. 27 to 29 and "120" for vol. 30. A reference number preceded by J is taken from the *Astronomischer Jahresbericht*. When no reference numbers were available, abbreviated journal references have been given.

QUASI-STELLAR OBJECTS, SEYFERT AND RELATED GALAXIES
(by E. M. Burbidge)

1. *Quasi-stellar objects*

A detailed review was published by Schmidt (*Ann. Rev. Astr. Ap.*, **7**, 527). This listed 296 references and covered the years 1967 and 1968. The first review in that series, by Burbidge (29-6492) covered work done between that discussed in Sandage's section of Report of Commission 28 (*Trans. IAU*, **13**, 579) and the period covered by Schmidt.*

Identification

For the 3C revised catalogue, Schmidt (30-7617) listed 44 identified and confirmed QSOs with relevant references. For the 4C catalogue, identifications have been suggested by Wills (29-6401); Barbon, Braccesi and Fanti (29-7858); Bailey and Pooley (29-13304); Olsen has an unpublished list of 68 on which Schmidt is making spectroscopic observations in the zone $+20°$ to $+40°$, with the proportion of correct identifications running about 60 %. Extensive lists of suggested identifications in the Parkes catalogue have been published, by Bolton and Ekers (28-10961), by Shimmins (29-14754), by Bolton, Shimmins and Merkelijn (29-14730), by Merkelijn, Shimmins and Bolton (30-4370) and by Merkelijn (30-11642; *Austr. J. Phys.*, **22**, 237). Two new areas in the 5C survey have been completed and searched for possible identifications: the 5C 2 by Pooley and Kenderdine (30-4379) and the 5C 3 around M31 by Pooley (*M.N.R.A.S.*, **144**, 101). Wills (30-14525) suggested some identifications for high-frequency sources. Mills, Shobbrook and Stewart-Richardson (30-4371) suggested several identifications among radio sources near Abell clusters of galaxies, observed at Molonglo and Arecibo. Thompson, Kraus and Andrew (30-7620) suggested identifications for some sources with peaked or flat radio spectra in the Ohio survey. The rapidly variable bright object BLLac has been identified with the Vermilion River Observatory source VRO 42.22.01 by Macleod and Andrew (30-4259) and Schmitt (29-14751); it may be either a QSO or N-type galaxy on the basis of its lineless optical spectrum. Hazard, Gulkis and Sutton (30-9767) have accurate source positions from lunar occultations and suggested several QSS identifications.

* The book *Quasi-Stellar Objects* by the Burbidges (J67-13445) should also be mentioned. – G. C. McV.

For correct identifications, accurate optical positions which enable comparison with the increasingly accurate radio positions have been measured by Lü and Fredrick (29-13506; 30-4366, -4367), by Véron (30-8567) and by Bolton (30-4226).

Candidates for radio-quiet QSOs have been selected by surveys for blue objects with UV excess with the Tautenburg Schmidt by Richter, Richter and Schnell (*Mitt. Taut.*, No. 38) and by Bronkalla (30-9622). Eggen (30-7518) and Barbieri, Erculiani and Rosino (*Publ. Padova*, No. 143) published lists of faint blue stars. Whereas such lists will contain a percentage of white dwarfs and hot subdwarfs, Braccesi (28-12524) showed that the presence of an infrared excess as well as UV excess makes identification virtually certain. Braccesi, Lynds and Sandage (30-604) and Janes and Lynds (30-13060) gave spectroscopic results on QSOs selected in this way. According to (30-604), the number of QSOs down to $B = 19{\cdot}4$ mag. may be 5 per square degree. Sandage and Luyten (30-14303) made a further study of 301 blue objects in high latitude, and concluded there may be 10^7 QSOs down to $B = 22$ over the whole sky.

Fanti-Giovanni and Fanti (28-12437) found many QSOs selected optically to be weak radio emitters; Lang and Terzian (*Ap. J.*, **158**, L11) observed 38 QSOs and compact emission-line galaxies and found weak emission at 318 MHz in 22 of them.

A catalogue of QSOs was published by Barbieri, Battistini and Nasi (29-14886).

Redshifts; distribution of redshifts

Redshifts have been determined by Kinman and Burbidge (29-3514); Dibai and Esipov (28-11035; 29-364, -5008; 30-4343); Ford and Rubin (*Carnegie Inst. Yrbk.*, **65**, 67); Schmidt (30-7617); Braccesi, Lynds, and Sandage (30-604); Shimmins, Searle, Andrew, and Brandie (30-4388); Schmidt and Olsen (*A.J.* **73**, S117); Lynds and Wills (30-2627); Bolton, Kinman, and Wall (30-11683); Burbidge (30-11684); Searle and Bolton (30-11707); Stockton (30-14612). Tabulations of redshifts can be found in Burbidge (29-6492), Schmidt (*Ann. Rev. Astr. Ap.*, **7**, 527) and Burbidge and Burbidge (30-1456). The latter included 31 related emission-line galaxies as well as 155 QSS and QSOs. The objects found by Braccesi, Lynds, and Sandage included some objects with very small redshifts and colors like Seyfert or N-type galaxies, and their physical properties may be more akin to these than to the "classical" QSS.

Burbidge (28-12527) noted that there seemed to be too many QSO and QSS with absorption-line redshifts at $z \approx 1{\cdot}95$ for a chance distribution. The distribution of redshifts was analysed by Burbidge (30-11688; 30-14561); evidence for two peaks at $z = 0{\cdot}061$ and $z = 1{\cdot}95$ was presented, and for possible peaks at integral multiples of 0·061. Cowan (30-7615) suggested an intrinsic pattern in the redshift distribution corresponding to $z = 1/6$ and 1/15. Barbieri, Bonometto and Saggion (30-13808) drew attention to two peaks in the redshift distribution for quasars (see also discussion by Tinsley, Patterson and Tinsley, *Ap. Letters*, **4**, 55). The peak at $z = 1{\cdot}95$ led Shklovsky (29-4670; 29-13519) and Kardashev (29-13040) to consider model universes of the Lemaître type, further discussed by Petrosian, Salpeter and Szekeres (29-144).

The lack of correlation between magnitude and redshift was further discussed by Longair and Scheuer (*Nature*, **215**, 919). The rather abrupt cutoff in redshift near $z = 2$ was displayed in a plot by Burbidge and Burbidge (*Nature*, **224**, 21). Brecher and Silk (*Ap. J.*, **158**, 91) discussed the absence of larger redshifts in terms of a Lemaître model universe, while Rees (*Ap. Letters*, **4**, 61) suggested that the apparent deficiency at $z > 2$ might be due to the onset of absorption by intergalactic atomic hydrogen if this were largely neutral at epochs corresponding to $z > 2$.

Emission line intensities; Physical conditions in emitting regions

Most of the papers giving determinations of redshifts contain approximate eye estimates of relative intensities of lines. Wampler (29-3525; 30-2639, -11682) measured line intensities in some quasars with a photoelectric scanner and discussed physical conditions. Wampler and Oke (29-5027) studied the spectrum of 3C 273 in detail and detected faint features due to Na I and permitted Fe II lines. Burgess (29-6494) calculated that the size of the emitting region of a cosmologically distant quasar in which [O II] is seen must be 10^2–10^3 pc. Osterbrock (*Liège Coll.*, 1968) discussed the calculated and observed intensities of several emission lines; discrepancies led him to calculate new collision strengths for [C III] λ1909 and other semi-forbidden emission lines.

Sargent and Searle (30-7618) found that the Hβ emission intensity was similar in many quasars and related emission-line galaxies and did not agree with recombination theory. An overlying non-thermal continuum and coupling between thermal and non-thermal radiation could explain the observations. Bahcall and Kozlovsky (30-14555) calculated detailed models for 3C273, giving the distributions of various stages of ionization. The results suggested relative abundances of the elements similar to solar values, except that He may be underabundant by a factor ~ 10, as suggested earlier by Osterbrock and Parker.

Absorption-line spectra

Absorption lines have been found in the spectra of some quasars and have proved more puzzling and intriguing than the emission lines. Bahcall, Sargent and Schmidt (29-6490) made a further analysis of 3C 191 and, from measured equivalent widths of the absorption lines, found a carbon-to-silicon abundance ratio $\sim 2{\cdot}5$, i.e. lower than the solar value, but Bahcall *et al.* (*P.A.S.P.* **79**, 425) found a higher ratio ~ 7. Grewing and Schmidt-Kaler (30-9849) made a similar analysis. Bahcall (29-6489) derived lower limits on electron density or radiation density in 3C 191 from the fact that fine-structure states in Si II are populated.

Most interesting are PKS 0237-23, PHL 938 and Ton 1530, with absorption lines belonging to more than one redshift system, quite different from the emission-line redshift. Burbidge, Lynds and Stockton (30-607) discovered five discrete absorption-line redshifts and two possible ones in PKS 0237-23, the largest at $z = 2{\cdot}202$ and the smallest at $z = 1{\cdot}365$, whereas $z_{em} = 2{\cdot}223$. PHL 938, with $z_{em} = 1{\cdot}955$, had absorptions at 1·906 and 0·613. Ton 1530, with $z_{em} = 2{\cdot}046$, had absorptions at 2·055, 1·980, 1·936. Bahcall (30-4334) derived a formal method of searching for and testing separate redshifts with a computer; using it, Bahcall, Greenstein and Sargent (30-4335) detected five redshifts in PKS 0237-23, and there was a good measure of agreement between the independent studies by Burbidge *et al.* and Bahcall *et al.* Bahcall, Osmer and Schmidt (30-14556) found two more redshifts in Ton 1530, at 1·921 and 1·887.

PHL 5200, earlier found by Lynds to have a supernova-like spectrum with emission lines at $z = 1{\cdot}98$ and broad absorptions extending down to $z = 1{\cdot}88$, was observed one and two years later by Burbidge (30-606, -13051) for possible changes due to expansion of the shell of gas. Structure in the form of absorption dips at $z = 1{\cdot}950$ and 1·891 was found. The latter paper also discussed the radio-quiet QSO B194 which was found to have absorption lines at $z = 1{\cdot}895$ and 1·837.

The above papers discussed the possible origin of the absorption lines, either in expanding shells at very high velocity, in intervening galaxies or intergalactic clouds at lesser redshifts, or in shells at different gravitational potentials. All suggested explanations encountered difficulties. Burbidge and Burbidge (30-14561) thought the spectroscopic arguments and statistics favored expanding shells particularly since rather similar absorptions were found in the Seyfert galaxy NGC4151. Peebles (30-10873) suggested "dead" galaxies in intervening space. Bahcall and Spitzer (*Ap. J.* **156**, L63) suggested extended halos around intervening galaxies. Probabilities for screening in Lemaître universes were calculated by Petrosian *et al.* (29-144) and Roeder and Verreault (30-3522, -6355; 30-13834). Roeder (*Ap. J.*, **157**, L153) found Bahcall and Spitzer's suggestion incompatible with Friedmann universes. Wagoner (29-13428) calculated strengths of UV lines expected to be produced in absorption.

Continuum energy distribution, UBV photometry, IR measures, variability, polarization

The papers by Wampler and Oke already listed also give continuum energy distributions. Grewing and Lamla (39-4352) derived a mean continuum. Schmidt (30-7617) and Lari and Setti (29-7870) derived mean continua from *UBV* measures. Bahcall and Sargent (29-3502) and Grewing (29-7868) calculated colors for $z > 2{\cdot}3$ and 2·2. Moroz and Dibaj (30-2630) observed 3C 273 and some Seyfert galaxies at 1–2·5 μ.

Kinman (30-4853) has produced a review of our knowledge of variable galaxies. Optical monitoring of QSOs was continued by Barbieri and Erculiani (30-8549). Cannon and Penston (28-12541) followed the rapidly variable 3C 446 and Wampler (29-3524) measured its continuum distribution during variations. Kinman *et al.* (30-616) found the variations in luminosity and polarization in 3C 345 to be quasi-periodic, with periods ~ 80 and 321 days. Angione (30-9829) discovered rapid variations in 3C 454·3 on old Harvard plates and Lü and Hunter (30-9856) gave a light curve for it with a suggested period of 340 days. Bolton and Wall (*Ap. Letters*, 3, 177) found large brightness variations in some QSOs. Kunkel (29-14899) made a harmonic analysis of variations in 3C 273.

Kinman (29-3513) found polarization in 3C 279 and 3C 345, and none in PKS 0405-12 and PKS 0837-12. Appenzeller and Hiltner (29-6488) measured polarization in 14 QSOs and found it generally present, though not very strong; Appenzeller (30-7612) confirmed that 3C 273 has no appreciable polarization. Elvius (30-4347) measured 3C 273, 3C 279, 3C 345 and found variable polarization in 3C 279 and 3C 345. Visvanathan (30-2638) observed 14 QSOs for polarization and found it in PHL 658, PHL 1093, 3C 57, 3C 454·3, PKS 0736 + 01, PKS 2145 + 06, PKS 2349 + 09. Visvanathan (30-1432) found large polarization in BL Lac. Low and Kleinmann (30-11682) found large polarization in 3C 273 in the infrared at $1{\cdot}5\,\mu$.

Models and theories for QSOs; the nature of the redshifts

No satisfactory theory has yet been found. Although a majority favors the cosmological nature of the redshifts, the factors that led this to be questioned originally are still unexplained, particularly the distribution of redshifts, and the inverse-Compton-synchrotron paradox which is not present for variable Seyfert and N-type galaxies of comparatively low redshift. Bahcall, Schmidt and Gunn (*Ap. J.*, **157**, L77) found B264 to lie in a cluster of galaxies at the same redshift, but this is only $z = 0{\cdot}095$ and some of the galaxies in the cluster are brighter than B264. Oke (*Ap. J.*, **158**, L9) found the colors of B264 to be similar to Seyfert and N-type galaxies rather than to QSOs. To avoid the inverse Compton problem, proton-synchrotron emission in strong magnetic fields was suggested by Jukes (29-7869) and Rees (30-3645). Kinman *et al.* (30-616) proposed a rotating object radiating anisotropically. Relativistically expanding sources were discussed by Petschek (29-3544) and Rees and Simon (30-630). A model using the inverse Compton process itself was proposed for 3C 273 and 3C 286 by Takarada (30-2637, -13073). Piper (30-11704) and Dallaporta (29-131) discussed combined cosmological and gravitational redshifts. Shimoda (30-4389, -4390) proposed a theory for redshifts in terms of non-linear effects in a dense plasma.

Evolutionary properties required to explain the redshift distribution and number counts were treated by Rowan-Robinson (29-14937) and Schmidt (30-7617). Grewing, Pfleiderer and Priester (29-6499, -6505) and Mathez (*Astr. Ap.*, **4**, No. 1) discussed interpretations of the line spectra in terms of cosmological or local theories. Arp (29-3501; 30-598) continued work on pairs of radio sources including QSOs about peculiar galaxies, suggesting non-velocity redshifts. Wagoner (29-490) and van der Laan and Bash (30-633) discussed his statistics. Terrell (30-4395) discussed the proper motion of QSOs in his local Doppler theory.

For the energy source, the following were proposed: lagging cores in the expanding universe by Ne'eman and Tauber (29-13044), matter-antimatter annihilation by Alfvén and Elvius (*Science*, **164**, 911), galactic flares by Sturrock and Feldman (29-14906), the evolution of dense star systems by Gold (29-14921) and Ipser and Thorne (30-9289).

2. *Seyfert and related galaxies*

We include in this category Seyfert, N-type, other radio and compact galaxies, also other galaxies with peculiar nuclei or giving evidence of violent fragmentation. All are objects in which explosive or violent events appear to have occurred.

Seyfert galaxies

The proceedings of a conference on Seyfert galaxies held in Tucson in 1968 were edited by Pacholczyk and Weymann and published (30-11682) with plates and an extensive bibliography. Some of the papers at the Tucson conference were published elsewhere, more fully or *in toto*. Morgan (30-2629) described the optical forms of Seyfert and related galaxies. Sèrsic and Pastoriza (29-1944) presented statistics on galaxies with peculiar nuclei; the paper at the Tucson conference updated this and more than doubled the number of galaxies studied. De Vaucouleurs and de Vaucouleurs (*Pub. Dept. Astr. Univ. Texas*, Ser. II, Vol. II, No. 7) gave a summary of data on classification, frequency, structure and diameters of Seyfert galaxies, their luminosities, colors, spectra and estimates of distances and absolute dimensions. They also (*A.J.*, **73**, S174) measured effective diameters of the nuclei of eight Seyfert galaxies.

Oke and Sargent (29-14903) gave a detailed spectrophotometric analysis of NGC4151. Andrillat and Souffrin (29-13492) announced their discovery of spectral variations in the nucleus of NGC3516 between 1943 and 1967, with an interpretation in terms of the physical conditions. Fitch, Pacholczyk and Weymann (29-13501) discovered optical variability in the nucleus of NGC4151. Colgate (29-13543) discussed his theory of stellar coalescence and multiple supernova explosions for both QSOs and Seyfert nuclei. Sargent (29-14904) discovered the Zwicky compact galaxy I Zw 0051 + 12 to be highly luminous and to show Fe II emission lines (as does 3C 273). Oke *et al.* (29-13510) found the compact galaxy I Zw 1727 + 50 to be optically variable. Morgan, Smith and Weedman (30-620) described spectral variations in the nucleus of NGC4151 between 1956 and 1968.

Visvanathan and Oke (30-634) gave polarization measures for NGC1068 and used them to separate the non-thermal from the thermal radiation. Arp (30-2619) showed the redshift-apparent magnitude relation for Seyfert and N-galaxies to be steeper than the normal curve and to join the QSO region. Demoulin, Burbidge and Burbidge (30-2621) described the spectrum of NGC7714, which appeared related to Seyfert galaxies. Barnothy and Barnothy (30-4337, -9830) discussed their theory that QSOs are produced by galaxies acting as gravitational lenses and focussing the light from very distant Seyfert galaxies. DuPuy (30-4346) gave the redshifts for four Haro galaxies. Westerlund and Wall (*A.J.*, **74**, 335) presented *UBV* photometry for 14 QSOs, 8 N-type galaxies, 39 radio galaxies and 19 radio-quiet galaxies. Rubin and Ford (30-9864) gave velocity and line-intensity measures in NGC3227; the rotation curve gave a mass of 2.6×10^{10} $M_\odot$ and discrete high-velocity clouds were found in the nucleus.

Work apart from that described at the Tucson conference includes the following. Bardin, Chopinet and Duflot-Augarde (29-5004) found from a spectrophotometric study of the nucleus of NGC5548 that T_e appeared to vary with time. Ford, Purgathofer and Rubin (30-2625) described the spectra of NGC4151 and some planetary nebulae near 1 μ, noting the great strength of [S III] $\lambda\lambda$9069, 9532 in NGC4151. Souffrin (30-9869, 30-14610) gave a detailed spectrophotometric study of NGC1068, 3516 and 4151, including study of the physical conditions and mechanism of ionization.

Vorontsov-Velyaminov (29-11796) described the structure of the nuclei of Seyfert and related galaxies. Moffet (30-4371) compared the optical and radio positions for NGC1068, 1275 and M87. Takayanagi (30-4394) measured light variations in 3C 120 between 1928 and 1943. Walker (30-4405) measured the motions of high-velocity cloud complexes in the nucleus of NGC1068. Danielson, Savage and Schwarzschild (30-11685) measured the diameter of the nucleus of NGC4151 with the balloon-borne 36-inch telescope and obtained an upper limit of 0.″18. Wampler (30-11713) found that there was considerable reddening, attributable to dust, in the nuclei of seven Seyfert galaxies, from measures of [S II] lines in the infrared and violet. Peterson (30-14599) found variation in the nucleus of NGC1275. Osterbrock (*Ap. Letters*, **4**, 57) showed that the [Fe X] and [Fe XIV] emission lines observed in NGC4151 can be understood on the basis of the photoionization model of Williams and Weymann. Anderson and Kraft (*Ap. J.*, **158**, 859) discovered sharp absorption lines in the nucleus of NGC4151 occurring at three separate redshifts, similar to the multiple-redshift absorptions in QSOs and implying ejection of shells of gas.

N-type galaxies

Oke (29-13509) discovered 3C 371 to vary optically. Cannon, Penston and Penston (29-7864) discovered 3C 390·3 also to be variable. Sandage (29-13517) confirmed variability of 3C 371 during the course of *UBV* photometry of 13 N-type galaxies. Sandage (29-13518) announced optical

https://doi.org/10.1017/S0251107X00023798 Published online by Cambridge University Press

variations in 3C 109, 3C 390·3 and I Zw 1727 + 50. Visvanathan (29-13525) found that 3C 371 showed no significant polarization. Usher and Manley (30-4398) found long-term variations in 3C 371 from old Harvard plates.

Demoulin and Burbidge (39-9841) discussed the non-thermal optical flux from 3 Seyfert galaxies, 3 N-type galaxies, M 82 and M 87. The radiation could be synchrotron in origin; the variations set size limits according to $R < c\tau$ that did not violate the conditions for synchrotron losses to exceed inverse Compton losses, in sharp contrast to the case for the QSOs at cosmological distances. Grewing, Demoulin and Burbidge (30-9846) calculated the non-thermal flux from N-type and Seyfert galaxies for a range of possible physical conditions, and showed that *UBV* photometry alone was insufficient to separate non-thermal from thermal components, particularly when dust was present.

M 87 and other radio galaxies.

Felten (29-14890) discussed the radiation and physical properties of the jet in M 87. Arp (29-13493) discovered a faint counter-jet in M 87. Walker and Hayes (29-13529) measured the motions of high-velocity cloud complexes in the nucleus of M 87. Walker (30-4406) discussed the "orthogonal fan jet" in M 87. Friedman and Byram (29-6497) confirmed their earlier observation of M 87 as an X-ray source; Bradt *et al.* (29-13495) also detected it. Johnson (*Can. J. Phys.*, **46**, S481) further discussed this X-radiation. Haymes *et al.* (29-14896) detected M 87 as a probable source of hard X-rays.

Solinger (30-13071) discussed the observations of M 82, and suggested that it is a Seyfert galaxy seen edge-on but this is questioned by van den Bergh (30-14617). Sandage and Visvanathan (*Ap. J.*, **157**, 1065) measured the surface brightness, colors and linear polarization of selected regions of the outer filaments of M 82; polarization reached 32 % in one patch and the data supported the hypothesis of synchrotron emission by the filaments produced by electrons up to 4×10^{12} eV in magnetic fields 10^{-5} to 10^{-6} gauss.

Bahcall and Schmidt (29-7442) showed from measures of [O III] lines in radio galaxies over a wide range of redshift that the fine structure constant had not varied with time. Redshifts of radio galaxies were measured by Wills (29-3526); Burbidge (29-7863); and Sandage (29-13330). Moffet *et al.* (29-3518) identified 3C 17 with a galaxy, from precise coordinates obtained by lunar occultation.

Compact galaxies and galaxies with peculiar nuclei

Zwicky (29-7883) discovered the first two actual clusters of compact galaxies. He also (29-13531) described blue compact galaxies in the Leo A and Leo B clusters, which also contain normal galaxies. Zwicky (29-13530) discussed compact galaxies as being studded with neutron stars, and having the essential properties of QSOs. He discussed the nature of the redshifts.

Pastoriza (29-6504) studied the peculiar nuclei of NGC 1672, 1808, 2997, 5236, 7552 and measured the [N II] λ6584/Hα intensity ratio. Itoh and Kogure (29-3510) studied the strengths of a number of emission lines in nuclei of galaxies and concluded they were produced by collisional excitation (including the Balmer lines). Shobbrook and Shaver (29-3522) studied the nucleus of NGC 4945 from blue and infrared plates, and showed that the position of the radio source is associated with the nucleus. Walker (30-636) discovered the nucleus of NGC 4254 to have varied, from comparison of 1921 plates of Lampland with recent observations. Burbidge and Demoulin (*Ap. Letters*, **4**, 89) discovered that a small gas cloud is being ejected at 700 km s^{-1} from the nucleus of NGC 4939.

Miscellaneous work on galaxies, groups, or clusters suggesting explosive activity; cases of peculiar velocities

Kiang (29-13504) searched the Palomar Atlas and collected cases of Haro's violet galaxies showing peculiar jets and filaments. Sĕrsic, Pastoriza and Carranza (30-4387) published a description of a triplet of peculiar galaxies with high excitation and suggested that it resulted from a violent event in the past.

Ceccarelli and Dallaporta (29-7443) proposed a model for the formation of clusters of galaxies by the ejection of fragments from an original larger-mass plasmoid. Sĕrsic (30-630; 30-4386) discussed the possible formation of galaxies by fragmentation. Arp (30-4330) found lines of galaxies around large E-type radio galaxies and suggested they were formed by ejection from the radio galaxy.

Rudnicki (30-9865) suggested the nucleus of M31 may have been active in the past. Bonometto and Lucchin (30-13050) suggested a connection between present shapes of spiral arms and past activity of galactic nuclei, and applied their results to M31. Ford and Rubin (*Carnegie Inst. Yrbk.*, **67**, 286) measured velocities of blue objects in the Virgo Cluster and found a wide dispersion. Burbidge and Demoulin (*Ap. J.*, **157**, L155) found a blue shift in IC 3258, a small galaxy near the center of the area of the Virgo Cluster. Sargent (30-4383) found a remarkable distribution of red-shifts in the chain of galaxies VV172; four objects have velocities around 16000 km s^{-1} and one has 36880 km s^{-1}

GALAXIES IN GENERAL

(by G.C. McVittie)

1. Among studies of individual galaxies, the following may be cited. G. and A. de Vaucouleurs and K. C. Freeman (30-4404) deal with the kinematics and dynamics of the Magellanic-type barred spiral NGC4027. They used longslit spectra obtained with the B spectrograph at the prime focus of the McDonald 82-inch reflector. Tammann and Sandage (29-14907) have identified and classified 59 variables in NGC2403. The physical conditions in M51 and M81 that can be derived from the intensities of emission lines and of the continuum at various wavelengths form the subject of a paper by Peimbert (30-9860). NGC6822, a dwarf of the Local Group, and GR8, which may belong to the Local Group, have been studied by Kayser (29-1939) and Hodge (29-5015), respectively. The velocity, neutral H content, globular clusters or star clouds and reddening and distance of M31 are discussed by Rubin and D'Odorico (*Astr. Astrophys.*, **2**, 484), Brundage and Kraus (28-1875), van den Bergh (28-5477, 30-6360) and Schmidt-Kaler (29-6509). M. F. Walker (29-1946) has studied M33 with the aid of a two-color dye-transfer photograph. The distance of NGC3389 has been doubled – to 16·6 Mpc – by de Vaucouleurs (29-13524). A dwarf galaxy in UMi (van Agt, 29-11794), a peculiar galaxy (Burbidges and Shelton, 29-13496) and the peculiar galaxy NGC6438 (Sěrsic, 28-3054) have all received attention. Analyses of the nuclei of the following galaxies have been carried out: NGC4258 (Chincarini and Walker, 29-13498); NGC4486 (Walker and Hayes, 29-13529) and NGC4151 (Andrillat and Souffrin, 29-1931). Appenzeller (30-597) has determined the linear polarization of four spiral galaxies while Bertola (28-4256, 29-5005) gives the luminosity distribution of NGC4618/25 and of an extragalactic system analogous to Mayall's object. A discussion of the binary galaxy system NGC4631/4656 and the hydrogen "bridge" linking these two galaxies is due to Roberts (30-4380).

2. Discussions of the masses, rotations and luminosity distribution of galaxies are found in the investigations of the Burbidges (30-4341, -11689) on NGC1808 and 1832, and of Demoulin and Chan (*Ap. J.*, **156**, 501) on NGC6574. Masses turn out to be small multiples of $10^{10}\ M_{\odot}$. Chincarini and Walker (28-12529, 28-12540) have analysed galaxies of complex structure and rapidly rotating nuclei, Bertola and Bernaca (29-477) have determined the masses of NGC5005 and 6503, while Brandt and Roosen (*Ap. J.*, **156**, L59) argue that M87 has a mass of $2{\cdot}7 \times 10^{12}\ M_{\odot}$ and is the galaxy of greatest known mass. The de Vaucouleurs and de Cesare (*B.A.A.S.*, **1**, 186) have also derived the rotations and masses of nine galaxies. Takase and Kinoshita (30-631) have calculated the mass, angular momentum and energy for some 20 galaxies and found relations between these quantities. They interpret these relations in terms of the evolution of galaxies from proto-galaxies. Takase (30-592) has worked out the corresponding quantities for M31 and our Galaxy. Line widths have been used by N. Heidmann (*Astrophys. Letters*. **3**, 19) to estimate total masses and angular momenta. The rotation curve of M33 is the subject of a paper by Courtès and his colleagues (28-7064). Brosche (28-12525), through a statisticàl study of the rotations of 53 galaxies, finds a systematic difference in rotation between spiral and elliptical galaxies. Photometric data on galaxies lead J. Heidman (J66-14528, 29-5014) to conclude that there exists a relation of the form $L \propto A^q$ between absolute luminosity L and linear diameter A. Here $q = 2{\cdot}8$ for spirals and 1·9 for ellipticals. Spectro-photometric gradients of galaxies have been compiled by Vandekerkhove (30-9871).

3. Among analyses of the forms, stellar contents and colors of galaxies may be mentioned the classification of the forms and stellar contents of giant galaxies due to Morgan and Osterbrock (30-14596) who find three principal types: the Orion type with H II regions, giant blue stars and high gas density, the Intermediate, with absorption, spectral type F and high compositeness; and the Amorphous. McClure (30-13064) shows that CN absorption is stronger in the central cores of galaxies than in regions surrounding the nucleus. The stars in the cores of spirals and ellipticals are super rich in metals. *UBV* observations of field galaxies lead McClure and van den Bergh (30-14593) to conclude that the metallicity index has a lower value for non-cluster than for cluster glaxies. There are also investigations of three-color photoelectric surface photometry of six Sb galaxies by Simkin (29-11790); of eight-color photometry of galaxy nuclei by H. L. Johnson (27-10711) and of *UBV* observations and color diagrams by Shobbrook (27-12346) and Chiosi (29-482). An H-R diagram for galaxies is proposed by Firsoff (29-5011). The jets and filaments in Haro's violet galaxies have been studied by Kiang (29-13504).

4. The distribution in space and the clustering of galaxies have been discussed in many papers. Fairall (30-4348) has published a catalogue of compact and bright-nucleus galaxies. An examination of 1589 objects in the Tonanzintla Catalogue on the Palomar Sky Atlas by Prata (27-10717) revealed 16 non-stellar objects, 23 which might be stellar and 6 new blue non-stellar objects. The Lick counts have been analysed by Shane and Wirtanen (29-2025) for clouds of galaxies and the distribution in space, and also by Kalinkov (29-5016) for clusters and groups of clusters. From the same counts, Totsuji and Kihara (*Publ. Astr. Soc. Japan*, **21**, No. 3) have determined the correlation function for the spatial distribution of galaxies.

Catalogues of galaxies or of clusters of galaxies have been analysed for the existence of clusters of clusters and there is no general agreement on the matter. The papers by Kiang and Saslaw (30-14586), Kiang (29-484), Karpowicz (29-3512), Silk (29-14940), Reaves (*P.A.S.P.*, **80**, 564), Reaves and Stern (J67-145182) and de Vaucouleurs and Peters (30-7333) bear on these questions. The stabilization of clusters of galaxies by ionized gas is proposed by Woolf (29-3527). Zonn (30-4409) has evaluated the moments of the galaxies in a cluster. He finds that the mean number of cluster centers is 0·1 Mpc^{-3}. Three percent of all galaxies are members of pairs (30-4410) and, when redshifts are known, it turns out that the relative motion of a pair is hyperbolic. The forms and position angles of 4287 galaxies in the Hydra, Ursa Major, Virgo and Eridanus clusters lead F. G. Brown (29-14888) to the conclusion that, in each cluster, there is a preferred range for position angles.

King and Setteducate (29-11789) have calculated the rectangular coordinates of bright galaxies in de Vaucouleurs' catalogue to permit of identifications on the Palomar Sky Atlas. A catalogue of 139 galaxies south of $+20°$ Dec. from the Palomar Sky Atlas has been published by Glanfield and Cameron (29-9915). Questions regarding the relationship between the axes and the ellipticities of elliptical and irregular galaxies are dealt with by Rood and Sastry (29-1942) and Hodge and Hitchcock (27-10710).

With regard to individual clusters and groupings and their contents the review of present knowledge of the Local Group by van den Bergh (30-9872) may be cited, as well as the investigation of the dwarf galaxies it contains by Hodge and Michie (*A.J.*, **74**, 587). The distribution of intensity in the elliptical galaxies of the Virgo cluster is analyzed by M. H. Liller (28-9591) and the identification of dwarf galaxies in the center of the Coma cluster, by Reaves (28-7078). Descriptions and lists of clusters or small groups of southern galaxies are given by Klemola (*A.J.*, **74**, 804) and by Sĕrsic (29-7879).

5. In the study of H II regions and of other gaseous contents of galaxies, the catalogue and atlas of H II regions in 20 nearby galaxies by Hodge (30-13059) and the survey of Hindman (29-1938) may be noted. Other investigations of H II regions are those of Hodge (30-13058; *Ap.J.*, **156**, 847) and of Carranza *et al.* (*Astr. Astrophys.*, **1**, 449, 479; **2**, 1). Sĕrsic (*Z. Ap.*, **69**, 242) gives coordinates and diameters of 35 H II regions in NGC1313. Courtès and his colleagues have carried out an inter-

ferometer study of ionized hydrogen in M33 and of the H II regions of the N. E. arm of M31 (29-13497, 30-9840). The highly excited state of the gas in NGC4194 is discussed by Demoulin (30-14566) and the emission of Hβ in galaxies with strong emission lines, by Searle and Sargent (30-7618). The distribution of neutral hydrogen in NGC6946 has been analyzed by M. S. Roberts and his co-workers (30-11694). Maps of the integrated H I distribution in M31 have also been published by Roberts (29-9924). Although there is some H I in the central region of a spiral galaxy, the simplest description of the overall distribution is that of a ring, i.e., the H I is not centrally concentrated. In M31 the optically defined arms lie within this ring, close to the peak H I distribution. In M33, M101 and several other spiral galaxies, including the Milky Way, the spiral features lie interior to the H I ring. The optical spiral arms do not occur at the maximum of the beam-averaged brightness temperature distribution. Roberts has also derived an upper limit of 10^{-3} atoms cm^{-3} for the neutral hydrogen density in the halo regions of two edge-on galaxies, NGC4244 and 7640. The connection between neutral hydrogen and the dynamics of galaxies is dealt with by Guelin and Weleachew (30-9851, -9852) from the radio astronomical point of view.

6. Theoretical investigations of the dynamics of galaxies include the density-wave theory of C.C. Lin and his co-workers (29-2501, 29-7871, 30-14590), Ng's theory of a disk-shaped galaxy (29-13507) and the relation of gas and spiral structure due to Fujimoto (30-609). Orbits of stars in galaxies are discussed by Danby and Zahar (29-9909) and by Barbanis and Woltjer (29-19494). Sharpless and Franz (30-9866) look into the question of the degree of central concentration of mass in spiral galaxies. A review of the problem of the evolution of galaxies is due to Reddish (30-8563); a general theory of the development of a galactic nucleus or a compact globular cluster has been produced by Spitzer and Saslaw (27-12365, 28-12547). Questions concerning the background radiation and the upper limit of the mass density of galaxies are discussed by Peebles and Partridge (29-3519, -5021).

COSMOLOGY

(by W.B. Bonnor)

1. *Observational data*

Sandage (29-14469, 30-91) has derived a new redshift-apparent magnitude diagram for galaxies and radio galaxies. The diagram is restricted to galaxies which are the brightest member of a cluster, with a consequent small dispersion of $\pm 0\overset{m}{.}3$ about the linear Hubble relation. No significant deviation from this relation is observed out to the largest redshift involved, which is 0·46. Sandage also rediscussed the value of the Hubble constant H and obtained 75 $^{+19}_{-15}$ km s^{-1} Mpc^{-1}, although a value as low as 50 km s^{-1} Mpc^{-1} cannot be ruled out.

Measurements of redshifts, and of radial velocities generally, have been made by the de Vaucouleurs (29-6511) for 113 bright galaxies and by Rudnicki and Tarraro (*Act. Astr.*, **19**, 171) for six objects. Southern galaxies have been dealt with by Carranza (28-11034), Shobbrook (27-8219) and by D. S. Evans and collaborators (29-6496; 30-11690). All these observations refer mainly to bright galaxies with velocities of recession usually below 6000 km s^{-1}.

Pooley and Ryle (30-4378) have extended the radio source counts to fainter sources by using the 5C survey. Their new $\log N$–$\log S$ relation refers to an observing frequency of 408 MHz, the limiting flux density being 0·01 flux units. The observed slope is $-1{\cdot}85$ down to 3 flux units, where the curve starts to flatten off, reaching a slope of $-0{\cdot}8$ at 0·01 flux units. The integrated radiation from all the sources is about half the estimated extragalactic background at 408 MHz. A $\log N$–$\log S$ relation at a higher frequency (2700 MHz) has been obtained by Shimmins, Bolton and Wall (29-9762), who find a slope of $-1{\cdot}4$. It is not clear whether there is a discrepancy with the Cambridge results (29-13326; 30-4249; *B.A.N.*, **20**, 171).

Boynton, Stokes and Wilkinson (*Phys. Rev. Letters*, **21**, 462) have measured the microwave background at 3·3 mm, and obtained a temperature of 2·46 $^{+0.40}_{-0.44}$K. They regard this as consistent

https://doi.org/10.1017/S0251107X00023798 Published online by Cambridge University Press

with a black body spectrum, the measurements at longer wavelengths giving an average temperature of $2{\cdot}68\,^{+0.09}_{-0.14}$K. References to earlier measurements are given in this paper. Clauser and Thaddeus have published data on CN rotational temperatures based on the spectra of 8 stars lying in various directions in the Galaxy. All their results are compatible with a unique temperature of 2·7K at 2·6 mm. Bortolot, Clauser and Thaddeus (*Phys. Rev. Letters*, **22**, 307, 806) give upper limits to the temperature of the background at 1·32 mm (CN), 0·559 mm (CH) and 0·359 mm (CH^+). The first two limits are in conflict with the rocket measurements of Shivanandan, Houck and Harwit (30-9290) and Houck and Harwit (*Ap. J.*, **157**, 187) (who obtained a temperature of 8K in the wavelength range 0·04 to 0·13 cm), unless this far infrared radiation is confined to narrow lines.

The angular distribution of the microwave background has been studied by Conklin and Bracewell (29-6382), Partridge (*Am. Sci.*, **57**, 37) Penzias, Schraml and Wilson (*Ap. J.*, **157**, L49) and Conklin (30-13813). None of these workers found intensity variations down to a precision of 0·1 %, except Conklin who claims to have detected a significant 24-h variation, which he interprets in terms of the motion of the earth through the microwave background. The observed motion does not correspond to the rotation of the Galaxy or its motion relative to the Local Group of galaxies, but it does agree with the prediction of de Vaucouleurs and Peters (30-7333), who took into account the possible motion of the Local Group in a supercluster centered on the Virgo cluster of galaxies.

The intergalactic medium is the subject of a review article by Gould (30-8554) and the determination of its temperature is discussed by Gould and Ramsey (28-1878). The search for intergalactic hydrogen in the Virgo cluster has received attention from R. J. Allen (30-4327) and S. J. Goldstein (27-9442). The possibility of detecting a dense intergalactic medium by X-ray observations is considered by Henry *et al.* (30-2626). The X-ray emission observations from the Coma cluster seem to give contradictory results according to H. Friedman *et al.* (28-11036). Felten *et al.* (28-9857) argue that the emission must come from intergalactic matter. The diffuse X-ray background has been discussed by Silk (30-4392, -9868) and the general position is reviewed by Bunner *et al.* (*Nature*, **223**, 1222).

The helium problem has been thrown into a confused state by further evidence that the helium abundance in the Galaxy may vary with position. In particular some old stars appear to have a very low helium abundance. A brief review of this problem is given by Burbidge (*Com. Astr. Sp. Phys.*, **1**, 101), who also refers to some of the complications that can be introduced into the cosmological problem of helium formation in the hot big bang. Lynden-Bell (29-3516) has proposed that giant galaxies are perhaps helium rich.

2. *Properties of world-models*

Tables of values of useful quantities in a large number of zero-pressure world-models are now available through the work of Refsdal, Stabell and de Lange (29-6106). World-models with pressure are analyzed by Stabell (29-14470), Harrison (29-6101) and McIntosh (29-14458, 30-3522) and anisotropic models are investigated by Tomita (30-7331), Saunders (30-8285), Singh and Singh (30-3535) and Jacobs (30-3515).

McVittie (J66-4489) has shown that the special relativity formula connecting redshift and velocity of recession can be recovered in any world-model by appropriate definitions of distance and time-coordinate. Using a maximum redshift criterion, Crilly (30-8276) has reduced the number of observationally permissible models. Dulewicz and Zieba (30-3508, -3509) have proved some geometrical properties of Friedmann models applicable to redshift, angular diameter and photometric distance.

Petrosian and Salpeter (30-7327) studied ghost images in inhomogeneous Friedmann models and showed that simple focussing is impossible, the image being split into many images. Gunn (29-13037) has investigated the statistical effects of local inhomogeneities on the propagation of light, while Roeder and Verreault (30-3532) and Wagoner (29-13528) consider the effects of an intervening galaxy. McVittie with Schusterman (J66-134160) has shown from radio source counts that in uniform models these sources must have been more numerous in the past than now, and with

Ringenberg (*M.N.R.A.S.*, **142**, 1), that this conclusion is not altered by the use of differential counts.

Wilson and Edelen (29-1448) have shown that in inhomogeneous world-models the existence of a potential bound, such as the Schwarzschild limit, implies a positive cosmological constant and a lower bound for it can be calculated.

The theoretical consequences of the background radiation are discussed by Hawking and Ellis (29-14452) and by Narlikar and Wickramasinghe (29-3147, -13043). The primordial radiation in homogeneous anisotropic world-models is studied by Misner (30-7326).

3. *Cosmogony, origin of galaxies, etc.*

A general relativistic treatment analogous to the Newtonian treatment by Bonnor of gravitational instability in the expanding universe has been given by Arons and Silk (30-2353), and Nariai, Tomita and Kato (J67-44121). In an investigation of the origin of galaxies Harrison (30-8279) has argued that inhomogeneities were imprinted on the universe from the earliest moment of its expansion. The evolution and early stages of the Lemaître model form the subject of papers by Tomita (*Progress theor. Phys.*, **42**, 9) and Harrison (30-2361). Rawson-Harris (30-12549) has shown, by using perturbation theory in Newtonian cosmology, that a Lemaître model permits the formation of galaxies from a statistically probable fluctuation of the density.

The thermodynamics of a self-gravitating medium in quasi-static equilibrium, with applications to galaxy and stellar system formation has been studied by Saslaw (30-5911).

Peebles (29-143; 30-13035) has predicted the angular momentum of the Galaxy, using the theory of the formation of galaxies by gravitational instability. Tinsley (30-7367) has demonstrated that 'galaxies' resembling all normal types can be formed in about 12×10^9 years from the time when Population I stars begin to form, the sequence of types being, however, a non-evolutionary one.

The early evolution of the expanding universe, and chemical abundances have been studied by Japanese workers (J 67-44148; *Progress Theor. Phys.*, **41**, 840).

Radial motions of fluid spheres including cases of collapse, expansion and bounce have been investigated by McVittie and Stabell (J66-44207; J67-5596, -44113, *Ann. Inst. H. Poincaré*, **9**, 371) without prior imposition of an equation of state. Thompson and Whitrow (29-1723) have worked out a more general method and have applied it to uniform density cases with an arbitrary equation of state at the center. Similar cases are treated by Bonnor and Faulkes (29-7474) and by Bondi (30-10853). Buchdahl (28-10721) has dealt with static spheres with an equation of state while Silk and Wright (30-12588) discuss the collapse of a rotating sphere.

The appearance of a star collapsing through its Schwarzschild radius has been studied by Ames and Thorne (30-7318). Chandrasekhar (28-10722) has investigated the post-Newtonian effects of general relativity on uniformly rotating Maclaurin spheroids and the incorporation of Mach's principle in general relativity has been re-investigated by Lynden-Bell (29-6103).

Brief mention may be made of theories alternative to general relativity. The relation of quantum electrodynamics to the direct interparticle action theory of Hoyle and Narlikar (30-62, 30-13818, and references there given) is examined and found to support the steady state theory. Time-symmetric electrodynamics in Friedmann universes have been investigated by Roe (*M.N.R.A.S.*, **144**, 219).

A class of scalar gravitational Lorentz-invariant theories with a variable light-velocity has been set up by Page and Turner (29-13045). An article by Alfvén and A. Elvius (*Science*, **164**, 911) explains their views on antimatter, quasi-stellar objects and galaxy evolution. Hunter (29-7449) finds that no non-rotating model of Alfvén-Klein type with equal amounts of matter and anti-matter could have established a black-body radiation field at its minimum radius and then expanded to infinity.

Dicke (29-14447) has suggested that the He content of Population II stars could provide a test for comparing general relativity and his scalar-tensor theory. Nariai (30-8281) demonstrates that the Brans-Dicke theory satisfies Mach's principle in a homogeneous isotropic universe.

EXTRAGALACTIC ASTRONOMY IN THE U.S.S.R.

(by B. Vorontsov-Velyaminov)

In 1968 Vorontsov-Velyaminov and Arhipova (30-6364) finished the publication of the Morphological Catalogue of Galaxies (MCG). It contains 30000 numbered galaxies down to $15^m.0$ and to $\delta = -33°$ with detailed descriptions and notes. Many new morphological types were discovered, one of which was later denoted by W. M. Morgan as cD. Together with Noskova, Vorontsov-Velyaminov (30-635) compared the descriptions of MCG galaxies with the classification proposed by G. de Vaucouleurs. They also published in the "Nonstable phenomena in galaxies" (*Bjurakan*, 1968) papers on galaxies with peculiar nuclei, Haro galaxies and interacting galaxies. Zasov (30-4408) showed that the "bridges" in the latter can be long-lived at the expense of the accretion from the intergalactic gas. Parsamian, Sahakian, Iskudarian and Shahbazian (*Aca**, **4**, 41) developed the statistical characteristics of the central condensations and super-associations in Sc, Sb, SB and E galaxies. Sharov (30-626, -2636, -8565) studied the space distribution of Novae, globular clusters and gaseous and absorbing matter in M31. The inclination of its central layer was studied by Makarenko (28-12535).

Colorimetric and spectrophotometric investigations were published by I. Pronik and Chuvaiev (29-7877; *Astr. Zu.*, **46**, 755) on NGC628 and on the jet in M87. Kallogljan (28-9585; 29-3511) dealt with Stephan's quintet and Parsamian (29-13511) with NGC3310 and 3351. Ogorodnikoff (29-13508), from dynamical considerations, claims that needle-shaped galaxies may be possible. By averaging the forms of the spiral arms Karachentsev (29-5017) concluded that they follow Archimedes rather than logarithmic, spirals. Zasov studied interacting galaxies statistically. Markarian (28-12536) discovered over 70 faint galaxies with conspicuous UV continua. Some of them happened to be of Seyfert type, as revealed by Khachikian (30-13078) and others. Pronik, Esipov, Dibai and Vorontsov-Velyaminov (29-6495, -7866; *Astr. Zu.*, **46**, 237, 240, 725) studied spectrophotometrically many Seyfert galaxies and proposed physical models for them. Studies of their variability were also carried out by the Crimean observers. Hagen-Thorn and Dombrovski (30-4365, -4351) measured the polarization in some radio sources. In M82 in particular, the polarization is ascribed to the dust rather than to the non-thermal emission. Nezhinsky and Ossipkov (29-7872) re-determined the luminosity function of field galaxies. Vorontsov-Velyaminov (29-13526; 30-6363, 30-14619) showed that, according to radio observations of the rotation of galaxies, the spiral arms as a whole are situated inside the region of rigid body rotation in the overwhelming majority of cases. He showed also that in physical pairs of interacting galaxies the directions of the arms (= of rotation?) are equally frequently in the same and in opposed senses. Pickelner (29-13512) proposed his version of the magneto-hydrodynamical hypothesis for the formation of spiral arms, while Marochnik and Suchkov (*Astr. Zu.*, **46**, 319, 524, 762) amplified the theory of spiral arms as the product of density waves in a two component model with differential rotation. Their theory explains the existence of the trailing and of the unwinding arms. Sizikov (29-3523; *Aca*, **5**, 317) improved the theory for calculating the distribution of density from the velocity curve and the photometry of a galaxy. The Genkins revised the tables of the masses of galaxies and their luminosity functions. With Ozernoy (30-6341), they found that for young galaxies the mass is proportional to the cube of the diameter. Zasov and Ozernoy (29-5028) studied the rotational momentum – total and per unit mass. Towmasian (28-5476, -9599; 29-11792, -13523; 30-4396) studied the galaxies of M82 type and measured in Australia, the radio emission from several hundred different galaxies. He has found a correlation between radio emission and optical peculiarities.

Karatchentsev (28-5473, -12531) confirmed the statistical nature of the phenomenon denoted as "superclusters of galaxies" and estimated the density of H I in clusters. He and Lipovezky (30-8558) estimated statistically the light absorption in clusters. Agekian and Suzmina (29-13491) calculated the distribution of intrinsic oblatenesses of galaxies in clusters. Nezhinsky and Osipkov (*Astr. Zu.*, **46**, 685) showed that the dispersion of velocities in clusters is dependent on the mass distribution.

* *Aca* stands for *Astrophysica*, published in the U.S.S.R.

A large calculated value indicates the presence of expansion. Karachentseva (29-13503) analyzed the distribution of dwarf galaxies in three clusters and Zwiagina (29-11799) did the same for the groups in MCG, using the notes in that catalogue.

Radio observations of galaxies with discussions of the results, were carried out by Kurilchik and Lekht (29-485, -3515; 30-4362) and their colleagues. Esipov and collaborators (29-5008, -5009; 30-4343, -8552), using image converters, studied the spectra of faint QSS, etc., by means of a 125 cm telescope. Komberg (29-6500; 30-4361, -8560) discussed the nature of the broad emissions in the spectra of QSS and suggested that they may be due to binaries. Vorontsov-Velyaminov opines that QSS form groups and clusters of galaxies by repeated fragmentation. Gordon (29-11707) is producing models of the structure and masses of the envelopes of Supernovae, QSS and Seyfert galaxies. Shklovsky (29-13519) considered the nature of the standard absorption spectra of QSS on the basis of special relativity. He explains the variation of the optical spectrum of 3C 345 by the clearing of clouds of Mg II in the frequencies of the resonance lines due to the heating by the stream of particles ejected from the nucleus. Ozernoy and Chertoprud (29-3189; 30-4353) analyzed the light curves of the QSS using a magnetohydrodynamical model. Shklovsky (28-11055) showed the possibility of various causes for the X-ray emission. Ozernoy showed that the plasma ejected by a magnetoid can condense into stars. Jointly with Sazonov, he calculated the spectrum and polarization of a radio source produced by a relativistic fission of its components. Ozernoy and Chernin (29-11490; *Astr. Zu.*, **45**, 1137) formulated the hypothesis of a dynamical character of pregalactic "photon vortices" and on this basis they developed a theory of the origin of galaxies.

Zelmanov showed that the space volume, the quantity of particles and the energy in a cosmological model can be infinite in one system of reference and be finite in another. Grĭšcuk (29-7446) elucidated the difference between the group and differential criteria of a space non-uniformity. He has found all metrics satisfying the second criterion proposed by Zelmanov. Grĭšcuk also showed that for a dusty space the general solution of the equations of gravitation contains an essential non-simultaneous physical singularity. The solution containing a simultaneous singularity is not stable. Grĭšcuk, Doroshkevich and Novikov showed that the solutions could be made isotropic. They gave formulae for the anisotropic surviving emission in the models described by the solutions which were obtained. The team headed by Zeldovich, which includes Novikov, Doroshkevich and Sjunjaev studied a large number of problems of relativistic cosmology: the residual emission at different epochs, the expansion of anisotropic models, gravitational instability and collapse, and the formation of galaxies by different types of perturbations of a Friedman model. At the critical density of 2×10^{-29} g cm^{-3} for the intergalactic gas, the universe is open (infinite).

G. C. MCVITTIE
President of the Commission

WORKING GROUP ON THE MAGELLANIC CLOUDS

(by A. D. Thackeray)

1. *General*

A Symposium* on the Magellanic Clouds was sponsored by E.S.O. in Santiago, Chile, in 1969 March in connection with the dedication of the E.S.O. Observatory at La Silla. Review papers on the Clouds have been written by Westerlund and Bok (*J. R. astr. Soc. Can.*, **63**, 105).

2. *Variables and the P-L relation*

Gascoigne (*Mon. Not. R. astr. Soc.*, **146**, 1) has prosecuted further his *P-L* work on Cloud

* Where no references are given, the reader should consult the Proceedings of this Symposium and also forthcoming issues of the *Mon. Not. astr. Soc. S. Africa*.