28. GALAXIES

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The present account refers mainly to research work published in the period 1973–1975. Due to the limited space available, and the rapidly increasing number of contributions in the field of Commission 28, it has not been possible to write an all-inclusive report. As in the previous IAU volumes, the report is not intended as a repetition of the summaries given in the *Astronomy and Astrophysics Abstracts*. In stressing the importance of certain areas of research, the personal views of the writer(s) cannot be entirely avoided.

On account of the great diversification in the field of extragalactic research it has seemed appropriate to divide the responsibility for this report among astronomers who are actively working in the various areas. Where possible, references are given by the numbers in the above-mentioned *Abstracts*; for papers published after 1975.01.01 commonly-used abbreviations for journals are used and volume numbers alone without years.

Attention may be called here to the numerous meetings and symposia that have been held during the past three years, or the proceedings of which have been published during this period. The First European Astronomical Meeting, held under the auspices of the IAU, convened in Athens 1972, and the proceedings have been published in three parts; extragalactic problems are confined to the third volume, 'Galaxies and Relativistic Astrophysics' (11.012.010). A part of the Second European Meeting, held in Trieste 1974, was devoted to problems connected with galaxies (proceedings in press). The Third European Astronomical Meeting, on the subject 'Stars and Galaxies from Observational Points of View', was held in Tbilisi 1975; in the extragalactic field the lectures referred to the structure of galaxies, the missing mass in galaxies, and observational aspects of the evolution of galaxies.

IAU Symposium No. 52, on 'Interstellar Dust and Related Topics' (10.012.022), includes some papers on dust in galaxies. Symposium No. 55, on 'X- and Gamma-Ray Astronomy' (09.012.002), gives reports on extragalactic X-ray sources. Symposium No. 58, on 'The Formation and Dynamics of Galaxies' (12.012.005), covers a number of important problems: the nature of the intergalactic medium, the redshift problem, the nuclei of galaxies, the gravitational interaction between galaxies, and the spiral structure of nearby galaxies. Symposium No. 63, on 'Confrontation between Cosmological Theories and Observational Data' (12.012.004), presents a review of observational aspects of cosmology in the light of current theories. Finally, IAU Symposium No. 69, dealing with the 'Dynamics of Stellar Systems' (1975), among other things compares theory and observations as regards the dynamics of galaxies of different types.

Among other important meetings, attention is again called to the 'Conference on the Role of Schmidt Telescopes in Astronomy' (08.012.014), jointly sponsored by the European Southern Observatory (ESO) and the British Science Research Council (SRC); the proceedings include some papers referring to the extragalactic field. A subsequent 'ESO/SRC/CERN Conference on Research Programmes for the New Large Telescopes' (11.012.021) deals with a number of extragalactic observational problems. Extragalactic observations outside the optical region have been discussed at the 17th and 18th Herstmonceux Conferences (10.011.020, 12.011.038).

1. GALAXIES IN GENERAL

A. *Survey Work; Catalogues*

Two new large Schmidt telescopes, in the first place intended for survey work, have been installed in the southern hemisphere during the past three-year period. The ESO 1-m telescope became operational at la Silla, Chile, towards the end of 1972. About one year later, the 48-in Schmidt telescope of the British Science Research Council started observations at Siding Spring, N.S.W., Australia.

It was decided that the ESO telescope should first undertake a fast survey in a blue waveband: II a-O plates combined with a GG 385 filter. The survey is referred to as the ESO (B) Survey (also termed the 'Quick Blue Survey') and covers 606 fields distributed at 5° centers from −90° to −20° decl. The limiting magnitude for a l-h exposure is approximately $21\overset{m}{.}5$. A systematic search of the survey plates is carried out at the Uppsala Observatory. The three lists completed till now (12.113.033-034, third list in press), which refer to more than 100 fields, include galaxies down to a limiting diameter of about 1'.0, in addition to all disturbed galaxies that are recognizable on the plates. The lists give coordinates, diameters, position angles, and descriptions. Later on it is intended to collect all the data, with the addition of apparent magnitudes, in one final extragalactic catalogue for the southern sky. Preparations are also being made to produce an atlas of peculiar and disturbed galaxies. The UK SRC telescope will first be used for a survey based on sensitized III a-J plates, the exposures being centered on the same 606 fields as those mentioned above. A first list (in press) of 'A Catalogue of Southern Peculiar Galaxies from the U.K. Schmidt Survey', referring to 36 fields, has been prepared by Arp and Madore. On a photograph reaching $B = 23$ a study of 3000 faint galaxies has been undertaken by Dodd and colleagues (*Monthly Notices Roy. Astron. Soc.* **171**, 329). – Accounts of present and future surveys with the southern Schmidt telescopes have been given by West (11.032.048, 11.041.023), by Cannon (11.032.049), and by Reddish (*Observatory* **95**.85).

A very comprehensive and detailed catalogue, based on the Palomar Sky Survey prints, has been published by Nilson (10.158.072). The 'Uppsala General Catalogue of Galaxies' gives information on about 13 000 galaxies down to a limiting diameter of 1'.0 and north of decl. −2°.5. The data include, among other things, coordinates, diameters, position angles, morphological types, and magnitudes; additional information is presented in detailed notes. The catalogue furnishes a material very suitable for statistical analyses.

'The Revised New General Catalogue of Nonstellar Astronomical Objects', published by Sulentic and Tifft (10.003.155), presents revised data for the 7840 objects of the NGC. The revision is based on the Palomar Sky Survey prints, with the addition of plates obtained from a number of southern observatories. The catalogue supplies a collection of basic data that are urgently needed by the observers.

For 821 galaxies of the 'Reference Catalogue of Bright Galaxies' optical positions, with an accuracy of a few seconds of arc, have been determined by Gallouet and colleagues (10.158.024); the list is a continuation of a previous paper with positions for 745 objects (05.158.076). The Palomar Sky Survey prints have been used by Corwin (10.158.137) to derive revised classifications for 1200 bright galaxies. The new results show good agreement with the earlier de Vaucouleurs types.

Valuable information on the sky survey has been presented by Lund and Dixon (09.041.014) in 'A User's Guide to the Palomar Sky Survey'.

Finally, attention is called to the plans announced in a circular letter by R. S. Dixon to compile a master list of the over 200 000 non-stellar optical objects known at the present time. A study is being made of the desirability of preparing and distributing full-size, clear plastic overlays for all of the Palomar Survey photographs, showing all these non-stellar objects.

B. *Measurements in the Optical, Infrared, Radio and X-Ray Regions*

In the past three years a considerable amount of work has been devoted to photometry of galaxies in the standard optical wavelength bands. Since most of these investigations will be

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included in the subsequent report by the Working Group on galaxy photometry and spectrophotometry, only a few comments on general problems will be given here.

Attention is recalled to the interesting comparison of electrographic, photographic and photoelectric results that has been made by Ables and Ables (08.158.026); the three different techniques were compared by studying the luminosity profiles derived for the galaxy NGC 4881. The dependence of magnitude on the aperture used in photoelectric measures has been studied by Kron and Shane (11.158.012) in the first of a series of papers on the magnitudes of galaxies. In a paper on the techniques of galaxy photometry Tifft (10.158.041) has discussed a new method for rapid estimation of nuclear magnitudes by iris photometry of photographic plates.

It has become apparent that a large fraction of the luminosity from many extragalactic objects is emitted at infrared wavelengths, a fact that has been emphasized by Stein (*Publ. Astron. Soc. Pacific* **87**, 5) in a summary of recent revelations of infrared astronomy. Among observations in the near-infrared we may recall the spectrophotometry by Barbon and D'Odorico (08.158.003) of the nuclei of NGC 221, 224, 3115, 4151 and 4406, also the measurements by Barbon and Capaccioli (10.158.146) of NGC 3628. The heavily obscured object Maffei 2 has been investigated by Spinrad *et al.* (09.158.052); combining optical, near-infrared and radio observations they concluded that the object is a Sbc spiral with a probable distance of 5 Mpc. In the far-infrared region, we wish to recall the observations by Rieke and Low (08. 158.057; *Astrophys. J.* **197**, 17; *Astrophys. J.* **199**, **L13**; *Astrophys. J.* **200**, L67) of a considerable number of extragalactic sources. Several observers have measured galactic nuclei: NGC 253 (09.158.066), NGC 253, 3034 (09.158.145; *Astrophys. J.* **198**, L65), NGC 1068, 4151 (11.158.005). A list of the numerous observations of the nucleus of the important Seyfert galaxy NGC 1068 has been given by Jones and Stein (*Astrophys. J.* **197**, 297), together with a discussion of the origin of the infrared emission.

The largest number of contributions is to be found in the field of radio astronomy. Due to overlap with the Report of Commission 40, the following account will be restricted to the most important of the recent developments.

A very important field of research has been opened up by the arrival of the high-resolving synthesis radio telescopes. Attention will in the first place be called to the comprehensive extragalactic program initiated by means of the Westerbork telescope. This instrument consists of ten fixed and two movable 25-m disks, and is operated as an Earth-rotation aperture synthesis telescope. The results published by van der Kruit, Oort and Mathewson (08.158.067), by Allen and Raimond (08.158.011), and by van der Kruit (10.158.087-088) give, together with earlier results, data for 44 large spiral galaxies, among them all fourteen spirals brighter than Harvard magnitude 10.5 above decl. +15°. A summary and general discussion of the results, and a list of the objects, has been presented by van der Kruit (10.158.089). All the observations are studies of the radio continuum brightness distribution at 1415 MHz (bandwidth = 4 MHz). The radio maps in many cases give detailed information about the three components that can usually be distinguished: nucleus, base disk, and spiral arm system. The nuclei of Seyfert galaxies appear to be the strongest radio emitters, about 100 times stronger than the nuclei of most normal galaxies; NGC 598 and 2403 exhibit exceptionally weak nuclei. As regards the observed spiral structure, the radio ridges are displaced towards the inner edges of the optical arms, thus confirming the conception of compression regions due to the action of density waves. Additional observations with the Westerbork telescope have later on been published by Allen, Goss and van Woerden (10.158.119), by Rots and Shane (11.158.014), and by Israel and van der Kruit (11.158.082). An up-to-date summary of the Westerbork work has been given in a report by van der Laan (12.033.036).

The twin-element interferometer of the Owens Valley Radio Observatory has been used for synthesis observations of neutral hydrogen emission in spiral galaxies. A number of different observers have investigated Maffei 2 (09.158.001), NGC 6946 and IC 342 (09.158.005), NGC 2403 and 4236 (09.158.085), NGC 5194 (09.158.039), NGC 7640 and IC 2574 (10.158.027), IC 10 (11.158.010), and NGC 5236 (12.158.113). Detailed maps of the H I distributions and of the radial velocity fields lead to a number of interesting conclusions.

A program of high-resolution observations at 5 GHz of extragalactic radio sources has been in progress at the Mullard Radio Astronomy Observatory. The eight elements of the Cambridge Earth-rotation synthesis system have been connected to provide 16 independent interferometer spacings, with a maximum of close to 5 km. The results obtained for 48 objects have been presented by Pooley and Henbest (12.141.083). The very detailed maps are accompanied by a table of important physical parameters. In a separate paper, Hargrave (12.158.037) has given the results obtained for M 82.

Among the traditional 21-cm hydrogen line studies of external galaxies the numerous results obtained by means of the Nançay radio telescope may be noted. The results refer to all types of objects, from type E to type Ir I galaxies. The investigations are published in *Astronomy and Astrophysics.* Attention may also be called to the long series of neutral hydrogen observations of external galaxies made by the Jodrell Bank telescopes. Reports have been given by Lewis and Davies (10.158.083-084), and by Dean and Davies (*Monthly Notices Roy. Astron. Soc.* **170**, 503).

In the X-ray region the main interest has been focussed on the results obtained from the *Uhuru* satellite, launched by NASA in 1970. The observational data have been published by Giacconi and colleagues in 1972 (08.142.101) and 1974 (11.142.035), the latter contribution being 'The Third *Uhuru* Catalogue of X-Ray Sources'. With a nearly complete sky coverage, the total number of sources has grown to 161. Although most of these objects are of galactic origin, the number of known extragalactic sources has been greatly increased. The Magellanic Clouds are near enough to allow the resolution of a number of individual sources. The intrinsic X-ray intensity of NGC 224 seems to be about the same as the total emission of all the Milky Way sources, whereas the well-known radio galaxy NGC 5128 has an intensity about ten times greater. Other intense sources are found among the Seyfert galaxies, as NGC 1275 and 4151, and among the clusters of galaxies. The total emission is for the giant clusters 10 to 100 times greater than would be expected from the combined contributions of the member galaxies, an indication that the X-rays may possibly originate in an intergalactic medium inside the clusters. For quite a number of the high-latitude sources the identifications of optical counterparts are still uncertain.

Other observations of extragalactic X-ray sources have been made by instrumentation carried on the *Copernicus* and on the *OSO-7* satellites. Results have been presented by Rapley and Tuohy (12.159.001), and by Markert and Clark (*Astrophys. J.* **196**, L55).

More details about extragalactic X-ray sources may be found in the Report of Commission 48.

C. *Luminosities and Masses*

The revision of the extragalactic distances makes necessary a zero-point correction to all previously published absolute magnitudes and log masses of galaxies. A report on the new distance scale, and on the Hubble parameter, is found in a subsequent chapter.

In an investigation by Sandage (08.160.008) the luminosities of E and S O galaxies in the Virgo and Coma clusters have been analyzed as a function of the $U-B$ index. There appears to exist a very pronounced correlation between magnitude and color, the linear relation extending over an interval of 8.5 mag. The analysis leads to an accurate determination of the difference in distance modulus between the two clusters, a result that agrees with the difference expected from the redshifts.

In a statistical study of integrated properties of galaxies measured in the 21-cm line Balkowski (10.158.076) has compiled a list of the luminosities, as derived by different methods, for 149 individual objects.

The luminosity function of galaxies has been studied by Holmberg (11.158.066) by means of the Palomar Sky Survey prints. By a statistical procedure, 174 physical groups of galaxies have been picked out; the groups are centered on prominent spiral systems, and are thus comparable to the Local Group and the M 81 group. The distribution of the absolute magnitudes, as based on redshift distances, seems to be well represented by an exponential curve for the E-SO-Ir galaxies, and a normal error-curve for the Sa-Sb-Sc spirals. Whereas the former curve rises continuously down to the observational cut-off, the luminosities of the spiral galaxies appear to have a definite lower limit.

The luminosity function for members of the Coma cluster has been studied by Rood and Abell (09.160.004). Two sets of independent magnitude measures appear to be in good agreement. As in the previous case, it seems possible to represent the magnitude distribution with an exponential curve with a hump (excess due to spiral galaxies?) in the brighter luminosity classes.

As regards the masses of individual galaxies, the traditional method based on the internal velocity field as determined by optical or 21-cm observations has been applied to a number of objects. NGC 224 has been studied by Emerson and Baldwin (10.158.074); NGC 598 by Warner, Wright and Baldwin (10.158.001); NGC 4321 by van der Kruit (10.158.145); NGC 224, 3031, 5457 by Roberts and Rots (10.158.006). Detailed mass models have been derived by Nordsieck (10.158.044) for 17 galaxies. All these papers also give valuable theoretical contributions, as studies of the problem of non-circular motions.

The internal radial-velocity dispersion method (virial theorem) has been applied by Richstone and Sargent (08.158.018) to NGC 221, and by Morton and Chevalier (09.158.008) to a number of E galaxies. The method has been applied also to the nucleus of NGC 224 by Morton and Thuan (09.158.056). An interesting variation of the virial theorem has been successfully used by Hartwick and Sargent (11.158.101) to determine the mass of NGC 224 from the motions of its globular clusters.

The list by Balkowski (10.158.076) gives information on the total masses (and the hydrogen masses) for all galaxies measured up to 1973. An attempt to determine the statistical distribution function for the masses of galaxies has been made by Holmberg (11.158.066).

The ratios of mass to luminosity obtained for galaxies of different morphological types have been analyzed by Chiao and Reinhardt (09.158.006), also by Balkowski in the above-mentioned paper. The variation of mass-luminosity ratio with distance from the nucleus of a spiral system has been discussed in several of the papers listed here. It has in most cases been found that in the outer disk the ratio is independent of the central distance. The observed correlation between mass-luminosity ratio and $B-V$ for spiral galaxies has been compared with theoretical relations for model galaxies by Sargent and Tinsley (12.158.016).

Attention is called to the current discussion on possible massive halos surrounding galaxies. The existence of such halos would considerably increase the masses, and the mass-luminosity ratios, as derived by the traditional methods. It has been argued by Einasto *et al.* (12.158.022), by Ostriker *et al.* (12.158.107), and by Freeman *et al.* (*Astrophys. J.* **198**, L93), that available observations indicate the presence of heavy coronas, the mass of a spiral galaxy possibly increasing linearly with radius out to very great distances. Contrary to these results, Burbidge (*Astrophys J.* **196**, L7) has shown that there is no unambiguous dynamical evidence for massive galaxy halos.

D. *Composition, Structure and Dynamics*

During the past three-year period a considerable number of investigations have been published on the contents, structures and velocity fields of galaxies of different types.

Attention may first be called to some results obtained for elliptical galaxies. Repeated attempts have been undertaken to try to detect 21-cm emission from neutral hydrogen in E galaxies, all with negative results. References are made to papers by Gallagher (08.158.064), by Bottinelli, Gouguenheim and Heidmann (09.158.114), by Knapp and Kerr (11.158.113), by Huchtmeier, Tammann and Wendker (*Astron. Astrophys.* **42**, 205), and by Shostak, Roberts and Peterson (*Astron. J.* **80**, 581). The elliptical members of the Local Group offer an opportunity for detailed studies of content and structure. By means of interference filters it has been possible for Ford, Jenner and Epps (10.133.005) to identify 26 planetary nebulae in NGC 185, 205 and 221. According to Hodge (09.158.157), NGC 205 has an anomalous color distribution due to the presence of O and B stars in the central area; twelve dark nebulae have been identified with a distribution similar to that of the OB stars. The eight globular clusters found in NGC 205 are about 2 mag. fainter than the clusters of NGC 224. It has been suggested by Hodge (09.158.159) that contaminating populations of young stars may be present also in other E galaxies, thus offering an explanation of the relation between absolute magnitude and integrated color found by Sandage (cf. prec. sect.). The structure of the Fornax dwarf system has been investigated by Hodge and Smith (11.158.019) by means of photo-electric surface photometry and counts of resolved stars; the counts show an excellent agreement with King's cluster model. Positions are listed for six globular clusters. The physical characteristics of giant stars in the Draco dwarf system have been studied by Hartwick and McClure (*Astrophys. J.* **193**, 321) by means of intermediate-band photoelectric photometry; the observations lead to certain conclusions concerning the metal content of the stars. It has been shown by van den Bergh (08.158.118, 10.158.132, 12.158.012) that the three new dwarf companions to NGC 224 earlier found by him are resolvable; the brightest stars have magnitudes comparable to those of stars in the outer regions of NGC 185. As regards objects outside the Local Group, it may be noted that spectral scans by Spinrad (08.158.090) and by Faber (09.158.027) of about 30 elliptical galaxies of widely different magnitudes confirm the previously indicated trend: intrinsic colors and line strengths are closely correlated with absolute magnitude at all luminosities. For the purpose of studying the evolution of the stellar population, new models for E galaxies have been constructed by a number of investigators: van den Bergh (08.158.071), Tinsley (08.065.096), Hillel (10.158.107), Rose and Tinsley (11.158.100), Larson (11.151.009), Larson and Tinsley (12.158.065).

Going over to the domain of spiral systems, we note the increasing interest for studies of the nuclei of these galaxies. Recent photometric and spectroscopic analyses of nuclei have been made for NGC 224 by Joly and Andrillat (09.158.126), for NGC 3031, 4826, 5194 by Warner (10.158.102), and for a number of galaxies by Alloin (10.158.025, 12.158.004) and by Alloin and Sareyan (12.158.003). Infrared observations of spiral nuclei have been summarized in a previous section. Various attempts to construct models in accordance with the observational data for the stellar population in the nucleus of a normal spiral galaxy have met with difficulties, possibly on account of the presence of gas and dust in the nuclear region. The earlier comparison of the nucleus with an elliptical galaxy appears to be of questionable value. For recent discussions of synthetic models we refer to Andrillat *et al.* (08.158.012), Baldwin *et al.* (09.158.094), and Joly (11.158.105). A serious problem is presented by the rapid and complex motions of stars and gas that have been observed in spiral nuclei, more recently by Rubin, Ford and Kumar (09.158.063) for NGC 224, by Ulrich (08.158.108) for NGC 1614, and by Anderson (11.158.033) for NGC 4151. The observations in many cases indicate high-velocity expulsion of gas from the nuclear parts. The physical causes of the violent activity in a spiral nucleus are still not fully understood. A review of current ideas about the nuclei, and a detailed list of references, has been published by Saslaw (12.158.084).

As regards the disks of spiral galaxies, the distribution of luminous matter is discussed in the subsequent report by the Working Group on galaxy photometry and spectrophotometry. The increasing number of 21-cm surveys have given detailed information about the extension and structure of the H I distribution. As a rule, the H I clouds extend far beyond the optical boundaries. Recent high-resolution observations have been reported for NGC 3031, 4258, 5194 by Oort (09.158.120), for NGC 598 by Wright (09.158.014), and for NGC 224 by Guibert (11.158.009). The mean H I space density is apparently more or less independent of the morphological type, in contrast to the total mass density which decreases along the sequence from SO to Sc and Ir I; cf. Kellman and Black (10.158.045).

Special interest has been devoted to two types of objects in the spiral disk: dust clouds and H II regions. The general properties of the dust distribution are well known: high concentration towards the principal plane of the galaxy, and condensations more or less coinciding with the basic spiral pattern. The dust clouds are observed by their obscuration and polarization effects; examples are given by the analyses by van Genderen (09.158.038) and van den Bergh (*Astron. Astrophys.* **41**, 53) of the dust distribution in NGC 224 as found from the magnitudes of cepheid variables and from the colors of globular clusters, and by the polarization measurements by Elvius (10.158.092) for a number of galaxies. For the various parts of a given galaxy the dust-to-gas ratio may be more or less constant: the absorption seems to be roughly proportional to the H I density. The bright H II clouds in a spiral system, which may be identified on $H\alpha$ interference-filter photographs, are generally located in or near regions of high obscuration. Investigations on H II regions in external galaxies have been made by a number of observers, *and results are now available for more than* 100 *galaxies. A review of the studies of* H II *regions,* and a complete list of all observational data available up to 1974, has been published by Hodge (12.131.554); the review includes an analysis of the spatial distribution of H II and its relation to galactic structure. Valuable information on obscurations and hydrogen clouds has been assembled by Lynds in the publication 'An Atlas of Dust and H II Regions in Galaxies' (1974). The atlas presents image-tube photographs of 41 spiral systems, representing all the types of the morphological sequence.

At this place attention may be called to the systematic search for extragalactic supernovae that is being made at the Palomar Observatory by Kowal and collaborators. During the period 1973–75 a total of 83 new supernovae has been reported (10.125.011, 12.125.022, *Publ. Astron. Soc. Pacific* **87**, 401).

A 'Bibliography on the Structure of Galaxies' has been published by Brosche, Einasto and Rümmel (12.002.037). This compilation is intended to serve as a basic list of references for studies of the inner structure of galaxies.

As regards the dynamics of galaxies, we wish to refer to the subsequent report on observed velocity fields by the newly formed Working Group on internal motions in galaxies, also to the recent IAU Symposium No. 58 on 'The Formation and Dynamics of Galaxies'. The proceedings of this meeting (12.012.005) present a detailed account of different problems related to the dynamics of galaxies, a report that will not be repeated here. A few notes may be added on recent contributions on the problem of the origin of spiral structures.

In a series of papers, the evolution of spiral arms has been discussed by Contopoulos (09.151.033, 10.151.023, 12.012.005, *Astrophys. J.*, in press). The analyses refer to the particle resonance in spiral galaxies and the properties of the density waves. Further discussions of the density-wave theory have been published by Wielen (12.151.018), by Mark (12.151.035), by Woodward (*Astrophys. J.* **195**, 61), and by Roberts, Roberts and Shu (*Astrophys. J.* **196**, 381). A general discussion on spiral structure has taken place at the Royal Astronomical Society (*Observatory* **94**, 266). Observations of the dynamics of spiral arms in individual objects have been made by a number of investigators, among them van der Kruit (NGC 4321, 10.158.145), Guibert (NGC 224, 11.158.009), and Tully (NGC 5194, 11.158.133).

Further data on the dynamics of stellar systems are found in the report of Commission 33.

E. *Tidal Disturbances and Eruptive Phenomena*

A partial disintegration of a stellar system may be effected by two mechanisms: disruption by outside tidal forces, or ejection of matter by an internal release of energy. The two cases are treated together, since the observational evidence does not always permit a clear distinction between the two types of events.

A list of peculiar galaxies and interacting pairs and groups in the southern sky has been published by Sérsic (11.158.067). It may be recollected that the ESO-Uppsala survey of the southern sky (cf. section A) includes all disturbed galaxies that are recognizable on the plates.

Photometric and spectroscopic observations of double and multiple interacting galaxies have recently been reported by Arp and Kormendy (08.158.119), King and Kiser (09.158.060), Graham and Rubin (10.158.002), Arp (10.158.014,080), Chincarini and Heckathorn (10.158.101), and Stockton (11.158.006,103). The observations refer to galaxies with conspicuous disturbances, among them objects from Vorontsov-Velyaminov's 'Atlas and Catalog of Interacting Galaxies', and from Arp's 'Atlas of Peculiar Galaxies'.

It has been noted that interacting systems have a tendency to be aligned in chainlike configurations. However, a theoretical analysis by Turner and Sargent (10.160.032) leads to the conclusion that chance formations of multiple galaxies that in projection look like chains ought to be comparatively frequent.

A valuable contribution to our knowledge of tidal interactions between galaxies has been presented by Toomre and Toomre (08.151.039, 10.151.038). The bridges and tails that result from close encounters have been studied by analyses of theoretical disk models. It is shown that after the passage of a small-size companion the outer portions of the primary galaxy may be deformed into a double-sided spiral arm structure; an encounter with an equal or more massive object may produce a long tail on the far side of the primary, and a transfer of matter on the near side. Striking reconstructions have been made of four specific interacting pairs, among them NGC 5194-95. Similar theoretical analyses have been undertaken by Lauberts (11.151.052). The loss of orbital energy has been computed for close encounters between spherical bodies, also the exchange and loss of mass.

Radio observations of interacting galaxies have been reported in a number of papers. According to Wright (11.158.059), who has made a survey of 44 interacting systems, no anomalous radio properties have been detected, which may be interpreted as evidence against a nuclear ejection origin of the observed deformations.

As regards galaxies with explosive internal activities, some new information is available for NGC 3034 and 5128. The nature of the emission from the filaments of the former object has been discussed by Van Blerkom, Castor and Auer (09.158.009), and by Mathis (10.158.004). The results of high-resolution observations of radio intensity and polarisation of the inner parts of NGC 5128 have been reported by Price and Stull (10.158.028); the X-ray spectrum has been studied by Tucker and colleagues (09.158.057).

Attention has again been directed towards objects of type Ir II, a class that according to Krienke and Hodge (12.158.137) probably consists of explosive and post-explosive galaxies, in addition to galaxies distorted by gravitational interaction. Studies of NGC 5195 have been made by Spinrad (09.158.144), and by Warner (11.158.087). A number of Ir II systems have been studied by Chromey (12.158.144). Observational evidence for an explosive event in the peculiar galaxy NGC 1569 has been presented by de Vaucouleurs *et al.* (12.158.183); this is an interesting case since the object probably is to be referred to type Ir I.

An isophotometric and photographic atlas of peculiar galaxies has been published by Schanberg (10.158.150). The atlas gives information on 63 single galaxies and 28 multiple systems which show distortions caused by internal explosions or by tidal interactions.

F. *Clusters of Galaxies*

During the past three years a considerable fraction of the total work in the extragalactic field has been devoted to clusters of galaxies. Most of the contributions deal with the following problems: the internal structure, the redshifts of cluster members, the possible existence of intergalactic mass, and the distribution of clusters in extragalactic space.

The apparent distributions of galaxies in and around a number of clusters have been determined by galaxy counts down to different limiting magnitudes by Bahcall (09.160.015, 10.160.008,039, 11.160.008), Noonan (11.160.011), Austin and Peach (11.160.022), and others. The analyses lead to determinations of the total extension of each cluster, also of the spatial distribution of the cluster members. In many cases the latter distribution seems to be adequately represented by an isothermal-gas-sphere model. Luminosity segregation, with the brighter cluster members more centrally concentrated than the fainter members, appears to be present in some clusters; this concentration supposedly indicates a corresponding segregation in mass.

New determinations of redshifts for cluster galaxies have been reported by a number of investigators, among them Rood *et al.* (08.160.005), Tifft (08.160.004, 09.160.001), Tifft and Gregory (09.158.058). The number has increased at a fast rate; for each of the Virgo and Coma clusters the redshift list now includes more than 100 objects. It has traditionally been assumed that, apart from the excessive dispersion, the statistical distribution of the redshifts in a cluster would offer no special problems. A contrary view has been expressed by Tifft (11.160.007, and other papers), who has found indications of a very complex redshift field in the Coma cluster: in the redshift-magnitude diagram the galaxies appear to lie in bands sloping to fainter magnitudes at higher redshifts; in the bands the galaxies tend to be distributed according to morphological type. The significance of Tifft's interpretation has been doubted by other investigators, among them Barnothy and Barnothy (11.160.014).

The attention has remained focused on the well-known and still unsolved problem of the 'missing mass' in clusters: if the individual masses are based on the conventional mass-

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luminosity ratios, even on somewhat increased ratios, the combined mass provided by the members of a cluster would be far too small to account for their mutual association. In a series of papers (cf. 12.160.029), Rood has studied the empirical properties of the mass discrepancy in groups and clusters of galaxies. The possibility, touched upon above, of reducing the velocity dispersion by assuming a non-Doppler redshift component will be further discussed in a subsequent chapter on anomalous redshifts. The presence of large amounts of intergalactic matter within the cluster would also remove the dilemma by providing the necessary mass to bind the cluster.

The models constructed for a gravitationally bound cluster generally utilize intergalactic gas, although intergalactic dwarf stars, dust and black holes have also been suggested. The material must be in a form that does not violate the observational data available. According to 21-cm observations, neutral hydrogen does not seem to be present in clusters in an amount sufficient to account for the missing mass. As an example, we may refer to the results reported by De Young and Roberts (11.160.013) for a number of clusters. It has been suggested, however, that the amount of gas may be larger than that inferred from the observations if the hydrogen is concentrated in high-density clouds that are optically thick to 21-cm radiation (cf. Smart, 09.160.016). The possible upper mass limits of an ionized medium have been discussed by a number of investigators, among them Holberg *et al.* (09.160.013) and Davidsen *et al.* (10.160.040). The general conclusion is, that the measurements of Ly-α, X-ray and radio emission seem to rule out cluster models that are bound by an ionized gas. Since it is not possible to give here a detailed account of the numerous investigations on the hidden mass in clusters, we beg to refer to the complete summary of the present research situation that has been published by Tarter and Silk (11.160.029). We may cite the final conclusions by these writers: the missing mass could possibly be a mixture of dwarf stars, high-density clouds of neutral and molecular hydrogen and a small amount of hot, ionized gas; a mixture of this type would prove the most difficult case to substantiate or invalidate observationally.

In conclusion, a short account is given of the efforts that have been made to try to determine the spatial distribution of clusters of galaxies. It may not be necessary to emphasize the cosmological importance of these efforts, the framework of the clusters presumably reflecting the general arrangement of galaxies in space.

The investigations have necessarily been based on the two catalogues available, by Abell (1958) and by Zwicky and collaborators (1961-68). On account of the unavoidable observational selection, an effect that increases very fast with increasing distance, the analyses have in the first place been concerned with the projected distribution of the clusters over the sky. As is well known, the earlier results point in two directions: an approximately random distribution, or a distribution dominated by superclustering tendencies. A result of the latter type has been reported by Bogart and Wagoner (09.160.022) from a nearest-neighbor statistical test based on Abell's catalogue; an analysis of the distribution of the angular distances from a cluster to its neighbors seems to indicate a superclustering tendency. A similar conclusion has been reached in an investigation by Hauser and Peebles (10.160.024), also based on Abell's clusters; the results obtained by a special method of analysis developed by Peebles are interpreted as direct evidence for the existence of superclusters. According to Holmberg (12.160.013), who has made an analysis of the Zwicky catalogues, the previous investigations have not paid sufficient attention to the disturbances produced by the local, small-scale variations in galactic absorption; for distant clusters also by the absorption (or selection effect) that is apparently caused by nearby clusters. If these disturbances are taken into account, all available observational data seem to be in perfect agreement with the assumption of an essentially uniform cluster distribution, also with the assumption of a random distribution for the dust clouds in the galactic absorption belt.

2. COMPACT GALAXIES, QUASARS AND RELATED OBJECTS

(P. Nilson)

A. *Survey Work. Identifications*

A compilation of all published identifications of extragalactic radio sources was made by Véron and Véron (12.141.075). The list contains 4022 entries for 2882 different radio sources published in 232 papers. The authors will keep the list up to date and it is available from them on request.

Kraus and Gearhart (*Astrophys. J.* **80**, 1) published a list of redshifts and radio spectral indices at 408–1415 MHz and 1415–6500 MHz for 179 QSOs. Identifications of 135 sources from the NRAO 5 GHz survey were made by Johnson (12.141.064). More than half were quasars or quasar-like objects.

Katgert *et al.* (09.141.022) made a 1415 MHz survey at Westerbork to detect radiation from blue stellar objects. Out of 99 objects four were detected and another four suspected to radiate near the detection limit. A second deep survey at 1415 MHz was made by Katgert and Spinrad (12.141.054). 14 sources were identified with galaxies and five with possible quasars.

In spectroscopic surveys in the fields of 77 4C objects and of 120 faint blue objects in the PHL and LB catalogues, Schmidt (12.141.079 and 12.141.080) found in total 83 quasars.

Khachikian and Weedman (12.141.104) compiled an atlas of 71 Seyfert galaxies. A collection of 37 spectra was presented.

New BL Lac type candidates have been proposed by several observers. Attention is called to papers published by Le Squéren *et al.* (08.122.087), Carswell *et al.* (10.141.080 and 11.141.123), Khachikian and Weedman (11.158.089), Crovisier *et al.* (11.158.301), Disney (12.158.309), Hagen-Thorn and Semenova (12.158.310), Pollock (*Astrophys. J.* **198**, L53) and Usher *et al.* (*Astrophys. J.* **198**, L57).

Optical positions of the first 507 objects in Markarian's lists were measured by Peterson (10.158.094). The accuracy is of the order of a few seconds of arc. Some corrections to the original Markarian lists were noted.

B. *Photometric Investigations. Variability*

The photometric history of OJ 287 was studied by Visvanathan and Elliot (09.123.032) for the period 1894–1973. Angione (09.141.098) obtained historical light curves of 20 quasars and three Seyfert galaxies from Harvard plates. The photometric history of PKS 0537 – 441 since 1892 was investigated by Liller (11.141.088) and of PKS 0048 – 097 for the years 1921–1955 by Usher *et al.* (12.141.072). The quasar ON 231 (W Comae) was studied by Pollock *et al.* (11.141.002) on blue plates from the period 1931 to 1952.

A large number of investigations have been concerned with BL Lac type objects. A discussion, principally dealing with BL Lac and OJ 287, has been published by Kinman ('Variable Stars and Stellar Evolution', *IAU Symp.* **67**, 573). Observations of BL Lac have been made by, among others, Rieke (08.141.032), Bertaud *et al.* (09.122.052), Visvanathan (09.141.007), Weistrop (09.141.031), Weistrop and Goldsmith (10.122.028), Folsom and Miller (10.122.140), Evseev *et al.* (10.122.184), Milone (12.158.317) and Véron (*Astron. Astrophys.* **41**, 423). Ekers (*Astron. Astrophys.* **38**, 67) made 21-cm observations from March 1971 to Sept 1972 and found variations in intensity and polarization.

Crane and Warner (09.141.010) studied optical variations of OJ 287, ON 231 and OQ 208. Visvanathan and Elliot (09.141.020), Goldsmith and Weistrop (09.141.045) and Frolich *et al.* (10.122.138) investigated the variability of OJ 287. Miller *et al.* (10.122.139) reported rapid optical variability of AP Lib. Andrew *et al.* (12.158.301) made nine-colour photometry of AP Lib and PKS 0521–36. I Zw 187 was studied on Harvard plates by Hall and Usher (09.158.037). The object shows a BL Lac type behaviour, with a total amplitude in the variations of $2\overset{m}{.}1$.

Selmes *et al.* (*Monthly Notices Roy. Astron. Soc.* **170**, 15) made optical monitoring of 36 quasars, galaxies and BL Lac type objects. Lü (08.141.115) monitored 25 QSOs and presented fine-structure light-curves of 3C 345 and 3C 454.3.

Miller *et al.* (12.141.107) found rapid optical variability in PKS 1514 – 24, with a magnitude change of $0\overset{m}{.}5$ in 20 min.

About 700 objects in the General Catalogue of Variable Stars were examined by Bond (09.158.064) in a search for extragalactic objects. X Comae and V1102 Herculis were found to be compact galaxies. Observations of X Comae have been reported by Barbieri (10.122.029) and by Bond and Sargent (10.158.082).

Huchmeier and Wright (12.158.119) reported short-term radio variability in the compact galaxy III Zw 2 during nine months in 1972–1973. Medd *et al.* (08.141.070) published results from five years observations of 84 radio sources at 2.8 and 4.5 cm. Hunstead (08.141.086) found large fractional variations at 4.8 MHz in the quasars CTA 102 and 3C 454.3 and the radio galaxies PKS 1504 – 167 and 1524 – 13. Dent and Kojoian (08.141.114) monitored 22 extragalactic sources at 7.8 GHz during 1969.0 to 1971.7.

Simultaneous radio and optical observations, especially of BL Lac type objects, have been made by Hackney *et al.* (08.122.078), Epstein *et al.* (08.141.105), Kikuchi *et al.* (10.141.090), Kinman *et al.* (11.141.050), Tabara *et al.* (11.158.303), Rieke and Kinman (12.158.308), Miller *et al.* (12.158.313) and Andrew *et al.* (12.158.302). There seem to be considerable evidences for the opinion that the optical and radio variations are uncorrelated.

At McDonald Observatory, de Vaucouleurs and de Vaucouleurs (08.158.027) made *UBV* photometry of the Seyfert galaxies NGC 3516 and 5548 and demonstrated variations in the nuclear luminosities. MacPherson (08.158.002) found brightness variations in the nucleus of NGC 6814. Netzer (11.158.029) made a photographic investigation of NGC 4051, NGC 3227 and Mark 79. NGC 4051 and Mark 79 were found to be variable on a time scale less than a month, with amplitude larger than $0\overset{m}{.}2$.

O'Connell and Saslaw (08.158.059) made Strömgren photometry of Mark 205. No variability larger than $0\overset{m}{.}05$ was found. Weedman (10.158.003) made photoelectric *UBV* observations of 92 Markarian objects and five other Seyfert galaxies, in total 28 Seyferts and 42 other galaxies with bright blue nuclei.

Broad-band photoelectric photometry of the high-redshift quasars OH 471 and OQ 172 has been reported by Wills (12.141.050).

C. *Redshifts. Spectrophotometry*

Burbidge and O'Dell (08.141.108) have published a list of 249 QSO emission-line redshifts, 56 absorption-line redshifts and 57 emission-line redshifts for compact objects.

The redshift of Ton 1530, $z_{em} = 2.047$, was obtained by Morton and Morton (08.141.109). Three systems of absorption lines with lower redshifts were found. Bahcall and Joss (09.141.011) identified five absorption redshifts in PHL 957. In an investigation of Mark 132, McKee and Sargent (09.141.134) found the redshift 1.721 9 for eight out of 24 absorption lines and weaker evidences for three lower redshifts. The same object was studied by Morton and Richstone (10.141.027), who derived column intensities for absorption lines of C IV and Si IV at $z = 1.732\,33$ and C IV at $z = 1.730\,84$. Strittmatter *et al.* (10.141.023) found $z_{em} = 2.08$ for 1331 + 170 and three lower absorption redshifts. Baldwin *et al.* (10.141.075) obtained redshifts of 14 quasars in a sample of 92 quasar candidates. Wills and Wills (11.141.097) found 26 new quasars in a spectroscopic study of 62 objects near Texas radio source positions, and redshifts were obtained for 30 quasars and galaxies. Strittmatter *et al.* (11.141.119) determined redshifts for 20 quasars and seven radio galaxies. Schmidt (12.141.079 and 12.141.080) obtained redshifts of 81 quasars; a corrected version of 12.141.079 has been published in *Astrophys. J.* **195**, after page 253.

Carswell and Strittmatter (09.141.038) found $z_{em} = 3.40$ for OH 471 (0642 + 44), which was the first known redshift larger than 3. A detailed study of the spectrum of this object was made by Carswell *et al.* (*Astrophys. J.* **195**, 269). 89 strong absorption features were found and four probable absorption redshifts were determined.

Wampler *et al.* (09.141.090) found the largest redshift hitherto known, as they obtained z_{em}

= 3.53 for OQ 172. Baldwin *et al.* (12.141.081) observed this quasar with the image-dissector spectrum scanner at the Lick 120-in telescope and found 175 absorption lines. An absorption-line redshift at z = 3.066 is well determined. Oke (11.141.063) discussed the absolute spectral energy distribution of OQ 172 and OH 471.

A computer code to identify absorption redshift systems was developed by Aaronson *et al.* (*Astrophys. J.* **198**, 13). The code generates and analyzes a large number of random spectra, which makes it possible to estimate the statistical significance of an identification. In a study of eight quasar spectra, many previously known systems were confirmed, but several systems were found to be statistically insignificant.

Boksenberg and Sargent (*Astrophys. J.* **198**, 31) found that several redshift systems in PKS 0237 – 23 have a fine structure, with a constant splitting ΔZ = 0.001 2. A similar splitting had earlier been found in Ton 1530 by Morton and Morton (08.141.109) and in Mark 132 by Morton and Richstone (10.141.027). It also occurs between two redshift systems determined by Wingert (*Astrophys. J.* **198**, 267) in PHL 957. The phenomenon has been further discussed in papers by Rees (*Monthly Notices Roy. Astron. Soc.* **171**, IP) and by Bahcall (*Astrophys. J.* **200**, L1).

Barbon (08.158.004) made new spectroscopic observations of the compact galaxy III Zw. 43. The spectra of I Zw 129 and II Zw 70 were investigated by O'Connell and Kraft (08.158.007). Carozzi *et al.* (11.158.098) obtained spectra of 14 compact galaxies at Haute Provence. Furthermore, Carozzi *et al.* (11.158.003) made optical and 21-cm studies of VII Zw 301, VII Zw 403, NGC 4861 and I Zw 41. VII Zw 403 was found to have a blueshift of –110 km s^{-1} and may be a dwarf compact.

Disney (09.158.107) found the southern spiral IC 4329A to be the most extreme Seyfert galaxy known, with Hα 13 000 km s^{-1} wide and a Hβ flux of 7×10^{42} erg s^{-1}. Martin (12.158.002) made spectrophotometry of six Seyfert nuclei and derived various physical parameters. Wills and Wills (11.141.81) observed eight quasar candidates among Markarian's objects; all eight were found to be galactic stars.

D. *Physical Conditions. Model Calculations*

Ptak and Stoner (09.158.018; 10.158.046) presented calculations of the Hα emission line in Seyfert nuclei, assuming that fast protons are ejected from a small source and stream outwards through a uniform, partially ionized gas. The same model was used by Ptak and Stoner (09.141.086) and by Stoner *et al.* (12.141.007) in calculations of emission-line profiles of the most intense quasar lines. It was further discussed by Hubbard (*Astrophys. J.* **198**, 57) and by Katz (*Astrophys. J.* **198**, 255). Hubbard proposed a revised model in which bursts of particles replace the constant flux, in order to explain observations of rapidly changing structures in emission lines. Katz raised arguments against the Ptak-Stoner model and discussed the strong hydrogen line cores which should be produced. Moreover, it was argued that the uniform plasma configuration should be unstable.

Emission-line intensities for 32 Seyfert galaxies have been presented by Adams and Weedman (*Astrophys. J.* **199**, 19). The ionization mechanisms and the possibility of dust reddening were discussed. Shields and Oke (*Astrophys. J.* **197**, 5) made a study of the emission-line spectrum of NGC 1068. The line intensities indicate a filamentary geometry. A model for the infrared radiation mechanism in this galaxy was presented by Jones and Stein (*Astrophys. J.* **197**, 297), who concluded that 85% of the 10μ radiation comes from dust grains in the nucleus.

Ulrich (09.158.062) made spectroscopic observations of the nucleus of NGC 4151 and presented a model of gas-cloud motions in the object. Adams (09.158.012) observed Mark 78 and demonstrated the presence of mass motions resembling those in NGC 1068 and 4151. Interference-filter photographs show the object imbedded in a network of filaments. Anderson studied the motions in the nuclear regions of NGC 7496 (09.158.143) and NGC 4151 (11.158.033).

The radio properties of BL Lac type objects were discussed by Altschuler and Wardle (*Nature* **255**, 306), who also gave a summary of references for the ten best studied objects. Evidences were presented that the objects are extremely young sources which still lack an extended non-variable optically thin radio structure surroundning them. The variability of BL Lac at low frequencies (31 and 74 cm) was studied by Stannard *et al.* (*Nature* 255, 384). The results seem to be in conflict with predictions from the expanding cloud model, and the variations resemble low-frequency activity earlier observed in some quasars. It is possible that the activities at high and low frequencies are uncorrelated.

A model for the high optical luminosity of QSOs was presented by Colvin (11.141.120). Ultrarelativistic electrons produced in an explosive event were supposed to pass through a small, moderately dense, magnetized region in which they produce a high density of photons by the Cherenkov effect. The inverse Compton effect elevates these photons to optical frequencies. Colgate *et al.* (*Astrophys. J.* **197**, L105) discussed a QSO model in which supernovae constitute the power source of the optical and infrared flux.

Blumenthal and Mathews (*Astrophys. J.* **198**, 517) calculated theoretical emission-line profiles in QSOs and Seyfert galaxies, assuming that small clouds are accelerated to high velocities by UV radiation and contained to high densities by pressure in the intercloud medium.

Photoionization model calculations of physical conditions in QSOs and Seyfert nuclei have been presented by MacAlphine (12.158.106).

Chan and Burbidge (*Astrophys. J.* **198**, 45) estimated emission-line strengths for 166 quasars and compiled a table of rest-frame equivalent widths (z = 0.06 to z = 3.52).

Several papers during recent years have discussed the possibility that gas clouds near quasars may be accelerated to high velocities by radiation pressure. Williams (08.141.102) investigated the conditions under which a cloud will be coherently accelerated. Photon production inside the cloud will give rise to a differential expansion which probably tends to disrupt it. Tarter and McKee (10.141.102) calculated the radiative acceleration in gases excited by power-law, bremsstrahlung and blackbody ionizing sources with application to the line-emitting regions in quasars and to X-ray sources. Opher (11.141.001) made calculations of cloud acceleration and found velocities $\ll c$. Mathews (11.141.058) further discussed the tendency to differential expansion and the possibility of pressure equilibrium with the intercloud medium. Kippenhahn *et al.* (12.141.016), assuming that a confinement mechanism exists, calculated the final velocities of gas in ionization and thermal equilibrium in the radiation field of a QSO. With a simplified model the calculations gave velocities which agree with observed absorption-line systems, if quasars are assumed to be located at cosmological distances.

Cohen (09.141.082) discussed a model in which the absorbing gas is part of the intergalactic medium or the extreme outer parts of the galaxies. McKee *et al.* (09.141.002) studied the ionization equilibrium of gas producing absorption lines in quasars. The authors argued that the gas in some cases must be located at large distances from the quasars.

E. *Distribution in Space. Cosmological Aspects*

The controversy concerning the distance of BL Lac is not completely settled, although the object has been definitively shown to be extragalactic. From model calculations, Visvanathan (10.114.057) derived an upper limit of the distance of 687 kpc. However, Altschuler and Wardle (*Nature* **255**, 306) obtained by similar arguments a possible distance interval of 200 kpc to 2000 Mpc. Oke and Gunn (11.141.059) claimed to have found absorption lines in the nebulosity surrounding the nucleus; these lines gave a redshift of 0.07. Wlérick *et al.* (11.158.302) found that the nebulosity resembles a galaxy at the distance 300 ± 80 Mpc, which is in accordance with the result obtained by Oke and Gunn. In a later investigation, however, Baldwin *et al.* (*Astrophys. J.* **195**, L55) could not confirm the existence of absorption lines in the nebulosity. Adams (11.158.056), treating BL Lac as an N galaxy plus a 'mini quasar' nucleus, derived the approximate redshift 0.022. Kinman (*Astrophys. J.* **197**, L49) studied the surface brightness distribution in the nebulosity and found it consistent with that of an E galaxy with the redshift 0.07 but not 0.02.

Disney *et al.* (12.158.311) found that AP Lib has both absorption and emission lines of variable visibility with the redshift z = 0.048 6. Disney (12.158.309) suggested that PKS 0548−322 is a BL Lac type object in a cluster of galaxies with z = 0.04. The radio source 0735 + 178 was identified by Carswell *et al.* (11.141.123) with an object showing BL Lac properties; but two sharp emission lines give z = 0.424.

Ulrich *et al.* (*Astrophys. J.* **198**, 261) has discussed three E galaxies which may represent an intermediate stage between normal ellipticals and objects of the BL Lac type.

Schmidt (08.141.029) has constructed models of the distribution of extragalactic objects in space that are in agreement with radio source counts at different frequencies. The models incorporate strong density evolution for quasars, and radio luminosity-dependent evolution for radio galaxies. The counts are definitely incompatible with the steady-state theory, whatever the interpretation of the quasar redshifts (08.141.097). Spectrophotometric and photometric work for a sample of 50 4C quasars has confirmed this steep density evolution.

Setti and Woltjer (09.141.075) found that quasars with steep radio spectra show a Hubble relation, which is not the case for orther quasars. This phenomenon was further discussed by Stannard (10.141.074), who considered the form of the radio spectra for 166 quasars with known angular size and redshift. Sources with concave spectra fail to show a significant Hubble relation, whereas other classes give relations which are consistent with a slope of 5. The Hubble diagram for the brightest quasars with z from 0.2 to about 2 was discussed also by Bahcall and Hills (09.141.019). A distribution consistent with the value 5 was found. Evans (11.141.083) discussed the radio frequency Hubble diagram for quasars.

Burbidge and O'Dell (10.141.022) found a slope in the redshift-magnitude relation less than the expected one for a Friedmann universe with $q_0 = +1$. Contrary to Bahcall and Hills, they found no strong evidence for the cosmological interpretation.

A correlation between redshift and scintillation visibility for quasars was reported by Harris (09.141.099) from observations of interplanetary scintillation of 203 quasars and radio galaxies. Using the same technique, Hewish *et al.* (12.141.102) made measurements of angular sizes of radio sources and found an absence of small-diameter sources at the largest redshifts. Van der Kruit (10.141.097) discussed the angular-diameter distribution of quasars and found it compatible with evolving universe models with physical evolution of quasars. Arguments against Rowan-Robinson's hypothesis concerning two quasar populations were presented, and serious objections were raised against the local interpretation of quasars.

Wardle and Miley (11.141.005) studied the structure of 39 quasars with the NRAO interferometer at 11.1 and 3.7 cm. A 'Largest-angular-size $-z$' diagram was presented for 166 quasars. A deficiency of large objects at large redshifts was interpreted as an effect of ram pressure confinement, indicating the presence of an intergalactic medium.

Stannard and Browne (11.141.053) made radio observations of nine optically selected QSOs in the direction of Abell clusters of galaxies. Only one object was found to be a radio source stronger than 40 mfu at 962 MHz, and its redshift is much larger than that of the cluster. A search for QSOs in the direction of 66 Abell clusters was carried out by Bahcall *et al.* (10.141.024). Eight objects with redshifts from 0.09 to 2.06 were found. More QSOs were discovered than was expected from field surveys, but the excess may be due to systematic errors in the magnitudes.

Różyczka (08.158.094) counted galaxies on Palomar Atlas prints and found a slight excess around quasars with redshifts smaller than 0.5. Oemler *et al.* (08.160.010) reported that the QSO 3C 323.1 is located at a distance of 6$'$.5 from the center of a compact Zwicky cluster and has the same redshift as the cluster. Stockton (10.158.066) found that the quasar 3C 37.43 with $z = 0.370$ is close to a faint galaxy with $z = 0.373\,6$.

On 200–in. direct photographs of quasars, Kristian (09.141.014) found that some objects show features which may be interpreted as underlying galaxies. The results are consistent with the hypothesis that all quasars occur in the nuclei of giant galaxies. Arguments for such a two-component model were given also by Silk *et al.* (09.158.065), who made scans of the nuclear and extranuclear regions of Ton 256. Sandage (09.158.055) found that the Hubble diagram of 12 N galaxies has the same slope, scatter and zero point as radio galaxies if the N galaxies are interpreted as a giant E galaxy with a quasar-like nucleus. No non-cosmological component in the redshift was found.

Penston and Penston (09.158.105) presented very deep integration prints of BL Lac and 3C 390.3. The light from an annulus centered on the nucleus of 3C 390.3 is probably emitted by stars. Walker *et al.* (12.141.133) made electronographic observations of 3C 120 and found a bright, semistellar source centered on a smooth, elliptical nebulosity with mean colour index B

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$- V = + 0.85$. The observations were consistent with the view that the object is an E galaxy with a quasar nucleus.

The nebulosity around 3C 48 was studied with the Lick image-tube scanner on the 3-m telescope by Wampler *et al.* (*Astrophys. J.* **198**, L49). They discovered on the northern side forbidden lines with redshift slightly larger than the redshift of the quasar. In this investigation no evidence concerning the presence or absence of a galaxy of stars was found.

3. REDSHIFTS AND HUBBLE PARAMETER

(G.A. Tammann)

A. *Redshifts*

A handbook article on optical redshifts has been written by Sandage (*Stars and Stellar Systems*, vol. IX). Baum and Florentin-Nielsen (*Bull. Am. Astron. Soc.* **7**, 412) have performed a fundamental experiment on the nature of redshifts: young and old photons have the same energy.

The number of available redshifts has been greatly increased both by optical and 21–cm observations. Particularly the latter have improved the redshifts of many late-type galaxies by about one order of magnitude. A compilation of optical redshifts has been published by Nilson (10.158.072) and Fredrick and Gutsch (11.158.122). An essentially complete catalogue of redshifts of bright galaxies has been compiled by the de Vaucouleurs (2nd ed. of *Reference Catalogue of Bright Galaxies*); these authors have determined also systematic errors of individual redshift sources (see also Lewis, 11.158.027). A comparison of optical and 21–cm redshifts was performed by Dickel and Rood (*Astrophys. J.* **80**, 584) and Huchtmeier *et al.* (preprint).

Redshift determinations of individual galaxies are too numerous to be mentioned here. The two largest bodies of new redshifts have not appeared during the report period: Sandage's observations of nearly all remaining Shapley-Ames galaxies, and Fisher and Tully's 21–cm redshifts for more than 1000 galaxies, predominantly of low luminosity. Redshifts have been determined for field galaxies by Balkowski *et al.* (9.158.026), the de Vaucouleurs (9.158.117), Lewis and Davies (10.158.083) and Dean and Davies (*Monthly Notices Roy. Astron. Soc.* **170**, 503), for ScI galaxies by Sandage and Tammann (*Astrophys. J.* **197**, 265) and Rubin *et al.* (10.158.020; more redshifts are announced), for Scd galaxies by Shostak (*Astrophys. J.* **198**, 527), for galaxies with supernovae by Barbon and Capaccioli (12.125.20), for dwarf galaxies by Balkowski *et al.* (12.158.008) and Fisher and Tully (*Astron. Astrophys.* **44**, 151), of peculiar galaxies by Peterson and Shostak (12.158.001), for Markarian galaxies by Arakelian *et al.* (10.158.053; 10.158.148), Bottinelli *et al.* (9.158.007; *Astron. Astrophys.* **41**, 61), Denisyuk and Lipovetskij (12.158.155), Huchra and Sargent (10.158.110) and Kopylov *et al.* (12.158.160), for compact galaxies by Ulrich (*Astron. Astrophys.* **40**, 337), and for radio galaxies by Sargent (9.158.118), Strittmatter *et al.* (11.141.119; *Bull. Am. Astron. Soc.* **7**, 427) and Colla *et al.* (*Astron. Astrophys. Suppl.* **20**, 1). Pairs of galaxies were observed by Karachentsev *et al.* (*Astron. Astrophys.* **41**, 375) and Turner (thesis Caltech), and galaxy groups by Rubin (12.158.036), Welch *et al.* (*Astron. J.* **80**, 77), and Chincarini and Martins (*Astrophys. J.* **196**, 335). With the improved redshifts many groups appear to be bound (Materne, 12.158.007; Materne and Tammann, 12.158.093, *Astron. Astrophys.* **37**, 383; Sandage and Tammann, 12.160.036).

The de Vaucouleurs (10.160.014) have elaborated their finding that E and S galaxies in the Virgo cluster have different mean redshifts; Sandage and Tammann (private communication), however, find from an enlarged sample no redshift dependence on galaxian type. New Virgo velocities were observed by Davies and Lewis (10.158.084) and Huchtmeier *et al.* (preprint). Other redshift observations in clusters are: Tifft and Gregory (9.158.058) and Gregory (*Astrophys. J.* **199**, 1) for Coma; Tifft *et al.* (9.160.018) for Cancer; Tifft and Hilsman (*Astrophys. J.* **199**, 16) for the NGC 507 cluster; Vidal *et al.* (*Astrophys. J.* **196**, L95) for A

1060; Robinson and Wampler (9.160.007) and Mirzoyan *et al.* (*Astrophys. J.* **196**, 687) for Shahbazian clusters; and Miller *et al.* (9.158.017) for a cluster containing a BSO. For A 1367 new redshifts were announced by Dickens and Henbest (*Quart. J. Roy. Astron. Soc.* **15**, 329) and Tifft and Tarenghi (*Astrophys. J.* **198**, L7). Gunn and Oke (*Astrophys. J.* **195**, 255), Westphal *et al.* (*Astrophys. J.* **197**, L99), and Sandage *et al.* (preprint) have spent a considerable effort to obtain many more redshifts for distant cluster galaxies.

B. *Hubble Constant* H_0

Survey articles on the Hubble constant have been published by Heidmann (9.162.049) and van den Bergh (9.162.050; *Structure and Evolution of Galaxies* (ed. by G. Setti), p. 247). Model considerations have led to somewhat contradictory results for H_0 (Gott *et al.* 12.162.081; Gunn and Tinsley, *Nature* **257**, 454). A new attempt to derive H_0 has been published by Sandage and Tammann in six papers (11.131.553; 12.158.033; 12.160.036; 12.158.162; *Astrophys. J.* **196**, 313 and 197, 265). Their primary distance indicators are cepheids which yield the distance to 11 Sc and Ir galaxies in the Local Group and M81 group. The brightest stars and largest H II regions are used as secondary distance indicators leading to the distance of the M 101 group (r = 7.2 Mpc, which is about twice the conventional value) and to 39 late-type field galaxies. These galaxies provide a calibration of van den Bergh's luminosity classes, which in turn gives the distance to the Virgo cluster (r = 19.5 Mpc) and of about 70 newly isolated, distant ScI galaxies ($v_0 > 3000$ km s^{-1}). They find $H_0 = 55 \pm 7$ (km s^{-1} Mpc^{-1}) within the Local Supercluster and for the Virgo cluster as well as for the distant ScI's, and small random motions of nearby galaxies (<50 km s^{-1}); the work is outlined by Misner *et al.* (10.003.89) and Sargent (*High Energy Astrophysics and its Relation to Elementary Particle Physics* (ed. by Brecher and Setti)). The distance independence of H_0 is supported by Bahýl' (11.158.047) and Teerikorpi (*Observatory* **95**, 105). H_0 would be decreased by ten percent if the revised Hyades modulus ($3^{\mathrm{m}}\!.23$) were used, and increased by the same amount if the absorption at the poles were not zero, but $A_B = 0^{\mathrm{m}}\!.2$ (in conformity with a constant H I/dust ratio, but contrary to photometric evidence). The low value of H_0 has two reasons which, according to Sandage and Tammann, had so far not fully been accounted for: (1) the properties of distance indicators depend typically on the size of the parent galaxy, and (2) the Malmquist effect (cf. Tammann, 12.012.004; Tercentenary Greenwich Symp.).

Support for $H_0 \approx 55$ comes from the important, new application of the Baade-Wesselink method to supernovae (Branch and Patchett, 9.125.003; Kirshner and Kwan, 12.125.037; for other evidence from supernovae cf. Rust, *Bull. Am. Astron. Soc.* 7, 279) and the requirement that the Galaxy (and M 31) be not excessively large (Tammann, Tercentenary Greenwich Symp.). Extensive photometry of globular clusters around Virgo cluster galaxies is in very good agreement with the above Virgo distance (Hanes, thesis Toronto); this result is nearly independent of the Population I distance scale.

Tully and Fisher (*Bull. Am. Astron. Soc.* 7, 426) found a good correlation between the 21–cm line width and the luminosity of S and Ir galaxies. They confirmed the above, large distance of the M 101 group; their very low Virgo cluster distance (13.2 Mpc), inferring H_0 = 80, has not been confirmed by Sandage and Tammann (private communication) using the same method and more extended observational data.

The Hubble flow was found to be isotropic by Bahýl' (11.158.047) and Sandage and Tammann ($\Delta H_0/H_0 < \pm 0.15$). Using the data of the latter authors Peebles (preprint) has found within these limits a Galaxy motion towards Virgo, while de Vaucouleurs (preprint) derived again from the same data very large deviations from a pure Hubble field. A more distant sample of ScI galaxies (Rubin *et al.*, 9.158.020; Rubin, Tercentenary Greenwich Symp.) shows a relatively small, but significant directional redshift dependence; these authors suggested a Galaxy motion of ~ 500 km s^{-1} perpendicular to the direction of Virgo. Hartwick (*Astrophys. J.* **195**, L7) has explained this result as an effect of interstellar absorption. Le Denmat *et al.* (*Compt. Rend. Acad. Sci. Paris* **280** B, 459; *Nature* 257, 773), Karoji and Moles (*Compt. Rend. Acad. Sci. Paris* **280B**, 609) and Jaakkola *et al.* (*Nature* **256**, 24) interpreted a roughly corresponding anisotropy, suggested by supernovae and other objects as a real velocity effect.

Guthrie (European Conf. on Astron., Leicester) reported that he found a large anisotropy in data by Sandage (10.160.006). All of these results are at least in mild contradiction with the isotropy of the 2.7–K radiation (Partridge, 12.066.036). Sandage (preprint) has found no indication for a velocity anisotropy from brightest members in nearby groups and clusters of galaxies. Forthcoming multicolor data by Sandage and Visvanathan for hundreds of field E galaxies shall shed more light on the important question of the (an-)isotropy of the local Hubble flow.

C. *The Deceleration Parameter* q_0

Davis (*Bull. Am. Astron. Soc.* 7, 236) has proposed that there is a chance to directly measure the deceleration of the expansion. From a formal interpretation of the redshift-magnitude relation of first-ranked cluster galaxies Sandage and Hardy (10.160.007) and Sandage *et al.* (preprint) obtained $q_0 = 1$; Gunn and Oke (*Astrophys. J.* **195**, 225) found from a photometrically less homogeneous sample a smaller value. These formal values need various corrections as for: (1) luminosity evolution of galaxies (Tinsley 10.158.021; Tinsley and Gunn, preprint); (2) dynamical interaction of cluster galaxies; (3) intergalactic absorption (Romano, 10.161.001; K.–H. Schmidt, 11.161.001); (4) imperfect focussing of a locally inhomogeneous universe (Dyer and Roeder, 9.162.007; 11.162.020). Abell (12.160.017) and Austin *et al.* (*Monthly Notices Roy. Astron. Soc.* **171**, 135) have proposed to use the magnitude of the inflection point of the cluster luminosity function instead of the magnitude of the first-ranked galaxy. Baum (12.012.004, p. 71) has determined q_0 from a redshift- (metric) diameter relation.

The increasing complexity of the interpretation of the redshift-magnitude relation has weakened the case for a closed universe; various arguments for an open universe have been advanced by Tammann (12.162.023) and Gott *et al.* (12.162.081). Others have invoked also a non-zero cosmological constant (Landsberg and Brown, 9.162.086; Omer and Green, *Publ. Astron. Soc. Pacific* **86**, 867; Gunn and Tinsley, preprint). The visible mass is not sufficient to close the universe (e.g. Gott and Turner, *Bull. Am. Astron. Soc.* 7, 412), unless one postulates very massive galaxian halos (Ostriker and Peebles, 10.151.041; Gunn, 12.162.049; Ostriker *et al.*, 12.158.107; Ostriker and Yahil, preprint; Einasto *et al.*, 12.158.109, 12.158.188), – which are contradicted by Burbidge (*Astrophys. J.* **196**, L7) and Materne and Tammann (Third European IAU Meeting, Tbilisi), – great numbers of dwarf galaxies (Arakelian, 9.162.072), and/or a massive intergalactic medium (Field, 12.161.005).

An argument, originally proposed by Sandage *et al.* (7.162.012), to measure the ratio of kinetic and potential energy in the universe from the effect of density enhancements on the Hubble flow (cf. Zeldovich, 12.012.004, p. 74) has been brought into a quantitative form by Silk (12.162.061). The results from this argument depend on the adopted (an-)isotropy of the local Hubble flow. Sandage (preprint) derived from it a very low value of q_0. Also Fall (*Monthly Notices Roy. Astron. Soc.* **172**, 23p.), using a similar argument based on the random velocities of groups, found an open universe by a wide margin.

Age arguments have been invoked by Sandage and Tammann (*Astrophys. J.* **197**, 265) to derive a low value of q_0, and by Unsöld (*Der Neue Kosmos*, 2nd ed., p. 376) to favor a closed universe.

Wagoner (9.061.005, 12.162.027) has shown that the big-bang nucleosynthesis of light elements can only be explained in a low-density universe (Reeves, 9.061.029, 12.061.039, 12.061.062; Peimbert and Torres-Peimbert, 12.159.007; Epstein and Petrosian, *Astrophys. J.* **197**, 281). The argument is not stringent for a non-zero lepton number universe (Yahil and Beaudet, preprint), and the observed deuterium could possibly be of stellar origin (Reeves *et al.*, 9.061.008; Reeves, 11.125,063; Ostriker and Tinsley, *Astrophys. J.* **201**, L51).

4. ANOMALOUS REDSHIFTS

(H. Arp)

Since 1972 a large number of individual research projects have been carried out on various aspects of the problem of anomalous redshifts. No lengthy, over all review of the problem has been made, however, since the debate was summarized in the book, *The Redshift Controversy* (Field *et al.* 1973) and the summary which was presented at the 1973 IAU Symposium in Australia (Arp, 1974). In the following report, which is intended to summarize the work on this subject between roughly 1972 and 1975, no attempt will be made to give an assessment of the entire problem as it stands today. Only the various investigations known to the author at this writing will be mentioned together in generally related categories. Hopefully more review and evaluation of this subject will take place as part of the IAU Colloquium entitled 'Redshifts and Expansion of the Universe', scheduled to take place at the Institut d'Astrophysique in Paris in September 1976.

The following report will be roughly divided into the two subjects: The question of non-velocity redshifts in quasars and the question of anomalous redshifts in galaxies.

A. *The Nature of Quasar Redshifts*

One significant piece of observational progress on the subject of quasars was made by a group at the Lick Observatory (Wampler *et al.* 1975). They measured the nebulosity on the north side of the prototype quasar 3C48 and showed it to contain forbidden emission lines of oxygen and neon. The lines were only 400 km s^{-1} different in redshift than the redshift of the central light and therefore made it very difficult to account for the redshift on any model utilizing a gravitational redshift mechanism. If, on the other hand, the redshift is assumed to be of cosmological nature the nebulous material around 3C48 comes out to be of the order of 100 kpc in diameter. This is an unprecedently large diameter for a spiral galaxy if the quasar is assumed to be the nucleus of a spiral which gives rise to the outer emission nebulosity. In a similar situation, the quasar-like nucleus of 3C120 has been shown to have nebulosity around it (Arp, 1975), which if at conventional redshift distance, would require a galaxy disk of about 120 kpc in diameter.

On the subject of apparent associations of quasars with galaxies, a number of new quasars have been discovered within a diameter or so of galaxies of various sizes. Quasars of redshift z = 1.94 and z = 0.73 were discovered near NGC 5682 and IC 1417 respectively. (Arp *et al.*, 1975). Each of these latter galaxies was in turn in the relationship of a small companion to an even larger galaxy nearby (NGC 5689 and NGC 7171 respectively). In a similar situation, 4C 61.2 (identified as a quasar by Wills *et al.*, 1973) was shown to have a redshift of z = 0.43 and be about a diameter away from NGC 3407 (Arp, unpublished). NGC 3407 is, in turn, near the larger spiral NGC 3435. The galaxy NGC 227 has a small companion spiral southwest of it. Browne and McEwan (1973) reported a quasar about 1′ just to the southeast of this small spiral. Now further careful identifications of optical objects in the Pks ± 4° declination strip by McEwan *et al.* (1975) show, among other identifications, another quasar about 7′ west of the above described quasar-galaxy doublet. Even more recent work by Arp and Sulentic (unpublished) shows the existence of still another (radio quiet) quasar about 15′ east of the quasar-galaxy doublet. This gives a total of three quasars all about V = 17.5 mag. in a rough line about 20′ with a small galaxy near the center of the line. Just north and east of the large, disturbed Sb spiral, NGC 772, Arp (unpublished) also reports one and possibly two new radio quiet quasars. Work by E. M. Burbridge and Arp (unpublished) on the stellar object identified with Parkes 1107 + 037 by Murdoch *et al.* (1974) with the Molonglo Cross has shown that it is a reddish quasi-stellar object of z = 0.96 very close to a small disturbed galaxy. Weedman (1971) published a list of nine blue objects close to large galaxies. Unpublished observations by E. M. Burbidge, P. Strittmatter and Arp show that Weedman number 8 is definitely a quasar and possibly number 6. Spinrad (private communication) shows Weedman number 2 is definitely a star. The statistics of the probability of physical association of these quasars and galaxies has not been analyzed since both the quasars and galaxies fill rather heterogeneous selection criteria.

All of the above are candidates for investigation of possible quasar-galaxy interactions, but so far all such investigations have been restricted to cases of brighter objects which have been known for a longer time. For example, one of the four 3C quasars that fell within 4′ of NGC galaxies, a very improbable event to occur by chance as calculated by Burbidge *et al.* (1971), one of these quasars was 3C 232. The latter quasar has been the subject of two separate radio investigations recently. One investigation was by Haschick and Burke (1975) with the 300-ft. radio telescope at NRAO. They see the hydrogen absorption line of NGC 3067, the nearby galaxy in the radio spectrum of the quasar but conclude there is no evidence that the quasar is not at its cosmological distance in back of the galaxy. Grewing and Mebold (1975), on the other hand, note hydrogen at the lower rotational velocities of the galaxy as missing. They conclude that ionization from a nearby quasar might account for this apparently missing hydrogen. The four nearest quasars to large galaxies had been previously analyzed optically by Arp *et al.* (1975). They concluded that in all four cases optical disturbances were seen in the galaxies which would be unusual to observe by chance, and therefore, probably associated with the ejection of the quasars.

In a paper of potentially great significance, Ekers, Fanti, Lari, and Ulrich (preprint) report a Bologna radio E galaxy, B2 0924 + 30 with extended radio sources in a line on either side of the galaxy. Further out along this line are three compact radio sources, two on one side one on the other. The whole configuration of five sources is aligned to within ± 1/2 deg. and the nearest compact source to the galaxy is identified with a stellar object. Multi-channel scans by Arp with the 200-in. on this latter object confirm that it is probably a quasar near 21st apparent magnitude.

Finally, several investigations have recently come to the conclusion that BL Lac objects have been ejected from quasars. First a paper by Condon and Jauncey (preprint) points out that of nine BL Lac objects known to them, four are non-stellar or in compact galaxies, four are within 20″ of galaxies and only one is isolated. They conclude these Lacertids have been ejected from galaxies on time scales of $10^6 - 10^7$ y. Craine and Warner (preprint) show an additional BL Lac object, OX 029, very close to a galaxy. Arp *et al.* (1975) have discovered yet another BL Lac type object very close to a small galaxy in a chain. This centimeter excess object brightened by more than three magnitudes in less than a month. Finally, these same authors (unpublished) report a BL Lac object about a diameter southwest of the large spiral galaxy NGC 6503.

B. *Anomalous Redshifts in Galaxies*

One puzzling result to emerge recently in the subject of redshifts of galaxies is the apparent anisotropy of the Hubble relation. Rubin *et al.* (1973) showed that luminosity class I spirals had slightly displaced Hubble relations in different regions of the sky. Some discussion has developed on this point (Sandage and Tammann, 1975). Now recent analysis by Guthrie (preprint) shows that the previously published data on brightest galaxies in clusters is non-random (as a function of direction in the sky) for redshift ranges between 4000 and 25 000 km s^{-1}. Additional independent analyses by Jaakkola, Karoji, Le Denmat, M. Moles, Nottale, Vigier, and Pecker (preprint) show that bright cluster galaxies, galaxies with supernova distances, and Seyfert galaxies all show the same anisotropy of Hubble relationship at intermédiate distance as the original Rubin-Ford effect. In this latter paper and in another analysis by Karoji, Nottale, and Vigier (preprint) the sky is divided into two regions, one covered by clusters of galaxies, and the other the remaining inter-cluster region. It is reported that the Rubin-Ford effect exists for objects located in the cluster areas but not for objects outside these areas. The discoverers of the Rubin-Ford effect interpret it as an effect of rotation of the local super-cluster. This is hard to reconcile, however, with the observed isotropy of the 3 deg. background radiation which most believe would show effects of 700 km s^{-1} or so rotation speeds. Some doubt the reality of the observed effect. Others accept the existence of the effect and attempt to explain it in terms of various kinds of new physical phenomena. This particular subject promises to be an area of lively debate and investigation for some years ahead.

On the question of redshifts of companion galaxies relative to their central galaxies, E. R. Harrison (1975) has published an analysis of companions in various groups of galaxies and finds no significant systematic redshifts for the galaxies in any of the groups. Since the data for the individual galaxies is not tabulated, however, it is not clear why this result differs from that of Bottinelli and Gougenheim (1973) for largely the same galaxies.

B. M. Lewis (1975) has compared redshifts determined from 21-cm radio observations against published redshifts derived from optical spectra for a number of galaxies. He has found systematic differences between the two kinds of redshifts which are a function of the galaxy type being measured. He attributes these differences to systematic errors in the measurement of optical absorption and emission lines. He makes some tests for evidence of non-velocity redshifts in his data and arrives at a null result. In particular, he tests for systematic redshift differences as a function of inclination. Jaakkola *et al.* (1975), however, analyze 25 galaxies and find that in most cases redshifts increase towards the far sides of tilted galaxies, an effect they judge to be not entirely accountable for by expansion of material within the galaxies.

An investigation of the chain of galaxies near NGC 247 has been made by Balkowski and Chamaraux (preprint). With the Nancay radio telescope they measure the neutral hydrogen to be normal for galaxies of that size, type and redshift. Therefore they conclude the galaxies not to be at the close distance of NGC 247 as suggested by Arp (1973). Another case discussed in the latter paper of a chain near a large galaxy is VV 150 near NGC 3718. Measurements with the Westerbork synthesis array (Schwarz and Van Woerden, 1973) in NGC 3718 show a truncation of the neutral hydrogen distribution on the side extending toward VV 150 suggesting perhaps that an expansion wave from the small active chain has pushed back the hydrogen gas on this side of NGC 3718.

Two peculiar groups of galaxies in the southern hemisphere, Calan 19-2 and 19-4, are reported by Melnick and Quintana (unpublished). Each group of galaxies has a compact galaxy apparently associated with it which has an excess redshift of 1400 km s^{-1} in the one case, and 1500 km s^{-1} in the other.

In the first of a series of papers dealing with the concept that redshifts can occur only in discrete values, Tifft (preprint) analyses the rotation curves of well-known, local galaxies. He concludes that the data support an interpretation that these galaxies are composed of two basic streams of outflowing material with an intrinsic redshift difference of 70–75 km s^{-1}. This work represents an extension of his earlier analyses of redshift-magnitude bands in clusters of galaxies (Tifft, 1974).

In a recent paper Wesson (1975) performs statistical analyses on various classes of astronomical objects, including bright stars, galaxies, planetary nebulae, quasars, and Arp-Atlas peculiar galaxies. He concludes that bright stars are non-randomly distributed. He also concludes that quasars and Arp peculiars are to a lesser extent, but still significantly, non-randomly distributed. He argued that the non-randomness in the latter two cases is physically meaningless.

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5. EXTRAGALACTIC RESEARCH IN THE U.S.S.R.

(B. A. Vorontsov-Velyaminov)

ABBREVIATIONS

AA = Astronomy and Astrophysics
AC = Astronomical Circular of USSR
Af = Astrofizika, Erevan
AL = Astrophysical Letters
ApJ = Astrophysical Journal
AZ = Astronomicheskij Zhurnal
AZLet = Letters to the *AZ*, Vol. 1, 1975
Crim = Crimean
IAM = Institute of Applied Mathematics, Moscow
Izv = Izvestia
Nat = Nature
SAO = Special Astrophysical Observatory, USSR
Soob = Soobschchenia
Stern = Sternnberg Institute

In 1975, Moscow University published the Fifth Volume of the Morphological Catalogue of Galaxies (MCG) from $-33°$ to $-45°$ in declination. As before, besides the description of common galaxies (in greater part formerly anonymous-unknown) it describes many interacting and peculiar galaxies. On the whole MCG already covers 0.87 of the whole sky. It gives names and description of 32000 galaxies, which some astronomers continue to call 'anonymous'. The photocopies of the plates made by several observatories of the southern hemisphere shall make it possible to expand this most homogeneous and most detailed catalogue over the whole sky. It contains many northern galaxies missing in Zwicky's catalogue.

Vorontsov-Velyaminov completed the compilation of part II of his Atlas of Interacting Galaxies. It contains 700 images, of which 500 are new, 100 were published by him formerly, but now could be represented with more details and were better studied, and 100 made in red light, with radioisophotes, etc. The Atlas emphasizes the study of chains and nests of galaxies, leaving out hundreds of more familiar interacting pairs. In contrast with part I and Arp's Atlas, part II gives the interpretation of every image and this leads to the concept of lasting fragmentation of galaxies and of gemmation of satellites. A comparison of the tidal theory of intergalactic filaments with observations is also made. The same author published (*AZ Let*No. 11) some hitherto unnoticed deformations in pairs which cannot be explained by the tidal theory. They are straight streams of stars connecting the components, besides the curved arms, emanation of twin satellites on thin short filaments, etc. They speak again in favour of the viscosity of the spiral arms and 'bridges', the former being perturbed as a flexible formation. The models in the form of a disc composed of test-particles not interacting with each other apparently are not adequate to explain the real spiral galaxies. Especially attentively were investigated M 51 (*AZ* 52, 491) and 160 systems of the same appearance (*AZ* 52, 692). The negligible mass of most of the satellites seen at the tip, or at both tips (!) of the spiral arms precludes the formation of the latter by tidal forces. A short exposition of the fragmentation hypothesis and of gemmation of companions, with many illustrations appeared in *AA* 37, 425.

Khachikian and Weedmann (*ApJ* **192**, 58) published the first atlas of spectra of Seyfert galaxies, of which Khachikian studied in detail spectrophotometrically mostly those which entered the Markarian lists (*IAU Symp.* **44**, 160; *Af* **9** 39, 139, 509, etc.) With high resolution he also studied peculiar and irregular galaxies and some interacting ones, in particular NGC 520 and the faint blue objects in its vicinity and in other places. For them and for the Markarian galaxies he established their physical nature. 40 of the blue Markarian objects according to him present the superassociations (the large H II regions) inside irregular galaxies. A list of 95 known Seyfert galaxies with their physical characteristics was published (*AZ* **51**, 300) by Vorontsov-Velyaminov and Ivanisević (Yugoslavia). The same list with comments and ample bibliography for each object was given by them in the *Soob. Stern. Inst. No. 189.*

I. Pronik, V. Pronik and Metik (*AZ* **51**, 457, 481, 1204; *Izv Crim Obs* **52**, 65; **55**; *IAU Symp.* **58**, 341; **67**, 313) systematically observed the changes of intensity of emission lines in N 60 1275, 7469 and other Seyfert and Markarian galaxies. They attributed these changes to temperature variations in the nucleus; Markarian galaxies were studied systematically. For many objects intensities and line profiles were measured. Including some new discoveries (*Af* **8**, 155; **9**, 487; **10**, 307) they and Lipovetsky brought the number up to 700. Their redshift was measured by means of light converters at several observatories by different combinations of the participants of the Crimea and Alma-Ata teams, namely Arakelian, Esipov, Dibay, Denisjuk, Lipovetsky, Chuvaiev, Pronik, Kopylov and others (*Af* **10**, No 3, **4**; **11**, 15, No. 3).

For some Markarian galaxies there exist now several determinations of z, made with similar small dispersions, while the interacting galaxies are completely neglected by the observers. Using a selection of compact galaxies from MCG Arakelian with his colleagues observed the redshift of more than 300 of them. More than 50% have bright lines in their spectra. Among them and the Markarian galaxies on the whole more than 50 new Seyfert galaxies were recognized. Variations of the Hα-line intensity in the spectra of NGC 1068, 3516, 4151 were measured photoelectrically with interference filters by Cherepashchuk and Lyuty (*AL* **3**, 165, *AC* 831).

Jankulova, Dibay and Esipov (*AZ* **51**, 464) studied spectrophotometrically the nucleus of Seyfert galaxy Markarian 79 and determined the pertinent physical parameters. Jankulova devised a spectrophotometric two-component model of Seyfert galaxies. The thickness of the gaseous layers, their localization and masses were determined.

The photometric and colorimetric morphology of the Markarian, spiral and irregular galaxies was studied from photographs at Burakan, Abastumani, Alma-Ata and Moscow observatories. Kalloghlian and Heidemann (*Af* **9**, 71; **11**, 229) concluded that the double Markarian galaxies are of recent origin, and studied statistically these galaxies in pairs with the regular ones. *UBV* surface photometry of NGC 520, 3077, 5360 and 4753 was completed by Artamonov, Bürngen, Shapovalov (*Izv SAO*, No. 8 and 13). A striking group which contains 5 Markarian galaxies was discovered by the Karachentsevs (*AZ Let*, No 5). Shahbasian had found, long ago, a group which she originally considered to be a very remote globular cluster. Recent spectroscopic observations have shown, however, that it is, in fact, a cluster of compact galaxies. Shahbasian found also several very remote compact groups of compact galaxies on the Palomar Sky Atlas, and in collaboration with Petrosian and other colleagues studied their magnitudes and colours. So it was found that most of them are red (*Af* **9**, No. 3, **10**, No. 1; 3; 4). Until 1975, with the collaboration of the Karl Schwarzschild's Observatory astronomers, over 200 such groups were found.

Further developing these discoveries, in a joint paper Ambartsumian, Mirzojan (Armenia) and Arp with Hoag (California), (*Af* **11**, 193) having established the criteria for the faint compact galaxies from $17^{m}_{.}5$ to $18^{m}_{.}5$ on the red charts of the Palomar Sky Atlas, studied 12 compact groups of compact galaxies by means of the 5-m and 4-m Kitt Peak telescopes. Their images are completely black and the objects are all red.

The compact galaxies in isolated pairs from the Karachentsev Catalogue, 80 in number, were studied for redshift by Karachentsev, Pronik and Chuvaiev with the help of the 2.5-m telescope. 48 of them showed emission lines and provided radial velocities from which the orbital masses were found (*Af* **10**, 441). Nazarova using multicolour photographs and spectrograms made the absolute photometry of the central regions of galaxies which contain hot (blue) spots in their nuclei, of peculiar and diffuse nuclei and galaxies of the M82 type. She constructed the physical models of these nuclei, studied the localisation of various emissions and calculated the physical parameters, velocities of gases, etc. (*Izv Crim Obs*, **48**, **50**, **52** and her thesis). 28 H II regions from multicolour photometry were studied in NGC 2903 by Grigorieva (*Izv Crim Obs*, **54**). She measured their fluxes in Hα, calculated their masses and their connection to the hot stars. Two teams of Crimean observers systematically measured the irregular variations of the circular and linear polarization of extragalactic sources.

Einasto and Kasik (10.155.050) found a close correlation between the colour and the *M:L* value for the old population of galaxies. Most of the Estonian astronomers under Einasto studied the problem of the 'hidden mass' in galaxies and their clusters. A team of nine astronomers has found that the mass contained inside the orbit of a companion becomes larger as its distance grows (11.158.054). According to them the existence of massive gaseous coronae around giant galaxies at the beginning of their evolution is confirmed by the segregation of the dwarf satellites according to their morphological type (*Nat* **252**, 111). They estimate that the content of gas in the coronae of galaxies is below 10% of the total mass (in press). They found that the luminosity function of companions in such systems has a minimum at a luminosity by $2^{\text{m}}_{.}5$ fainter than the luminosity of the brightest galaxy. In the centre, there is a compact group of giant galaxies within a radius of 0.1 Mpc, and the dwarf companions are spread to 1 Mpc approximately. They call these systems hypergalaxies. Therefore the Estonian astronomers consider the dynamical estimates of masses as reliable. From the mass of corona, they estimate the mass of the Local group of galaxies at 6×10^{12} M (*AC* 840). However, Komberg and Novikov (Preprint *IAM*, 1975, No. 3) believe that the concept of massive gaseous coronae is not supported by the data on UV and radio emission. In their view coronae consist of red dwarf stars.

From the anomalous colour indices at minimum light of the N-galaxies, Komberg concludes that they can be explained by the presence of hot giants in a quantity not less than 10^8 inside a radius of 3 kpc. Together with Sunjaev, Komberg explains (Preprint *IAM* No. 9, 1972) the high Röntgen luminosity of the galactic nuclei by the inverted Compton scattering of the infrared-peak quanta by the relativistic electrons which produce the radio emission. With Efremov and Vorontsov-Velyaminov he gave many arguments (ibid., No. 4, 1975) in favour of the cosmological nature of the redshifts in the spectra of Stefan Quintet members. The latter author showed that in some galaxies the greater diameter of the largest H II region reaches several thousand parsecs. Therefore in some cases the distance estimate made from the apparent angular diameter of the largest H II region can be much in error.

I. Karachentsev and V. Karachentseva (10.158.043) published a catalogue of isolated galaxies and isolated pairs of galaxies (11.158.057), and a catalogue of dwarf galaxies of the Sculptor type in the zones −36° and −42° of the Palomar Sky Atlas (10.158.050). A general study of the latter, as a whole, is contained in the thesis of V. Karachentseva (*Af* **11**, No. 2).

The Karachentsevs themselves or jointly with their colleagues in various combinations studied: the double galaxies spectroscopically (*Soob SAO* **11**, 52), their morphological differences from isolated galaxies, their favourite orientation in pairs (*AZ* **52**), the problem of the existence of multiple clusters (*AZ* **52**), and they compared the catalogues of clusters made by Abell and Zwicky (*Soob SAO*, **13**). The Genkins (10.158.048) studied some evidence of rotation of E galaxies and the distribution of their angular momenta, while Pavlova investigated the distribution of linear sizes (10.158.049) and luminosities (10.158.141). Gainullina studied the oblateness of galaxies in the Coma cluster (10.158.020 and 021). Zasov and Massakovskaja (11.158.008) found a correlation between the colour and *M:L* for flat galaxies, *M:L* varying from 0.5 to 7. Gorbachev numbered and calculated: the distribution of galaxies in some Zwicky's clusters and of clusters on the sky, the orientation in pairs, statistics of redshifts, etc. (dissertation and notes in *AC* and *AZ*). Vorontsov (10.158.007) compared Holmberg's original data and later microphotometric measurements, and showed that the apparent oblateness of the flat galaxies requires a smaller correction than that adopted by Holmberg and de Vaucouleurs. However, the outer isophotes, which are related to the faint spherical corona, tend to be circular, independently of the inclination and type of the galaxy.

Savchenko (10.158.108) calculated momenta and masses of flat galaxies and found no definite connection with morphological type, but some correlations still exist. Vorontsov (10.158.109) confirmed the statistical increase of the period of rotation with the growth of compression of galaxies. Karachentsev, sometimes with his colleagues, partly in connection with the problem of 'hidden masses' in systems of galaxies, investigated the possibility of their expansion (10.160.20, 158.037), developed a model of the dynamical evolution of the chains of galaxies (*Soob SAO*, No. 14, and estimated the masses of E-galaxies (*Acta Astr.* **24**, No. 4).

Vorontsov (*AC* 731, 1972) made a generalization of data upon the ring and nuclear galaxies and drew attention to them. Later, Freeman and de Vancouleurs continued this study.

For the first time in the U.S.S.R. several rotation curves and masses of galaxies were determined by spectroscopic methods. Namely, NGC 275, 949, 145 by Denisjuk and Pavlova (*AC* 797) and NGC 4096 by Metlov (*AZ Let* No. 11), who developed a method to evaluate the errors in the velocity curves and showed the illusory nature of the waves on these curves (*AC* 825).

Zasov (11.131.102) estimated the density of gas in the SMC and the intensity of the magnetic field and its ratio to the energy of relativistic electrons. The rate of star formation changes slower than p^2. In (*AZ* **51**) he confirms that ρ, which decreases with R, does not drop below the limiting value determined by the epicyclic frequency at a given R. He showed also in (*AZ* **5**) the effects of motion of flat systems through the intergalactic gas in clusters.

Einasto, in collaboration with Heidelberg astronomers, compiled a bibliography of physical observations of most galaxies for which such data exist (*Veroeffentl. Rechen Inst. Heidelberg*, No. 36).

6. WORKING GROUP ON THE MAGELLANIC CLOUDS

(B. E. Westerlund)

A. *General*

The Magellanic Clouds attract more and more attention from astronomers in both hemispheres every year. A large number of investigations have been carried out since 1972. The available space does not permit a complete review; and the reader is referred to Section 159 of *Astron. Astrophys. Abstracts* for further references. We recommend also the Bibliography, compiled by Kilmartin, for the years 1951–1972 (10.002.053) and (11.159.002).

Magellanic Cloud Research was discussed during one session of the ESO/SRC/CERN Conference on Large Telescopes in Geneva, 1974, and the four invited papers cover many topics (11.159.006; 11.122.117; 11.154.024; 11.159.007). A number of items were likewise discussed at the Thackeray Symposium at the South African Astronomical Observatory, Cape, in January 1975 (*Monthly Notices Astron. Soc. South Africa*, **34**, No. 4), and papers dealing with Magellanic Clouds Research have appeared at a number of IAU Symposia and Colloquia (e.g. *Symp.* **58**, **59**, **60**, *Coll.* **17**). Identification charts for stars in the SMC and the LMC have appeared (12.041.006) or are in preparation (12.159.013).

B. *New Observational Data*

I. *X-Ray Observations*

Five X-ray sources are now known in the LMC (Markert and Clark, *Astrophys. J.* **196**, L55) and one in the SMC. The latter, SMC X-1, has been identified with the binary Sk 160 (Liller, *IAU Circ.* 2468) and the identification has been confirmed (08.142.094) and a number of optical observations have been carried out (e.g., 09.142.109; 10.121.044). Possible optical candidates for the LMC sources have been proposed (09.142.121; 12.113.051; 12.142.041) and the X-ray observations have continued (12.159.001; Tuohy and Rapley, *Astrophys. J.* **198**, L69) confirming the variability of LMC X-1, X-2, X-3 and possibly also LMC X-5. Soft X-ray surveys have likewise been carried out (12.159.012; Rappaport *et al.*, *Astrophys. J.* **196**, L15) revealing a possible emission from the LMC Bar.

II. *Supernova Remnants*

Following the discovery by Mathewson and Clarke of new supernova remnants in the SMC (08.125.027; 09.125.042) and in the LMC (09.125.010) the total number known is 14. A review has been presented by Mills (12.125.051). The ejection of radio sources from supernova remnants has been discussed by Mathewson and Clarke (09.141.009) and by Danziger and Dennefeld (in press). Line identifications and estimates of relative emission-line intensities have been given for N 49 (10.125.029) and N 63 A (*Astron. Astrophys.* **36**, 149).

III. *The Brightest Stars*

Fehrenbach and his colleagues have continued to identify LMC members by their high radial velocities, using the Fehrenbach objective-prism technique: Thus (09.159.007) lists 88 members and (11.112.017) 398 members of the LMC and 1434 foreground stars. All the known LMC members are identified on the charts previously referred to (12.041.006). High velocity stars found between the LMC and the SMC and between the LMC and the Galaxy have been studied by Carozzi (12.112.003). Accurate photometry is needed to determine the nature of some of the less luminous (class III) of these stars. Martin and Rousseau have detected more than 250 new O–B2 stars in the LMC (11.159.003; see also 08.159.012) and Brunet *et al.* list 272 new objects of this class (*Astron. Astrophys. Suppl.* **21**, 109). Fehrenbach and Duflot (08.159.007; 08.159.011) have found a group of LMC stars with abnormally strong hydrogen lines and weak ultraviolet radiation and $M_v \sim -6$.

Fehrenbach reports also that the objective-prism plates have shown a large number of emission-line objects which it has often been possible to classify. A catalogue of 80 Wolf-Rayet stars is being puplished and 200 other emission-line objects are being studied.

In the SMC an objective-prism survey to $m_v \sim 14.8$ has been carried out by Azzopardi and Vigneau (*Astron. Astrophys. Suppl.* **19**, 271) yielding many new members. A general catalogue is under preparation: Osmer (10.159.008) concludes from observations of the 45 brightest stars in the LMC that in general they are similar to the brightest stars in the SMC. He finds (10.114.056) for two SMC B 1.5–B 2.5 supergiants that they show weak N, O, Si and probably Mg and C; He content is normal. The line weakening implies a deficiency of a factor of 4. Spectra of 26 supergiants in the SMC are studied by Dubois *et al.* (*IAU Symp.* 72).

Some of the M supergiants originally identified and classified by Westerlund from objective-prism spectra have been observed photoelectrically (10.114.103) and spectroscopically (11.114.162). The classification, in the MK system, confirms the previous classification.

Isserstedt (*Astron. Astrophys. Suppl.* **19**, 259) has carried out photoelectric photometry of 392 supergiants in the LMC, and also discussed their intrinsic colours and individual distance moduli (*Astron. Astrophys.* in press). JHKL photometry of LMC stars has been obtained for 13 stars by Glass (12.113.004). A selection of red stars in a small region of the LMC, near 30 Dor, by UV and I photography has been attempted (10.113.029), and photographic *UBV* photometry to $V = 17$ has been used to identify faint OB stars (10.113.026). The possible carbon stars, identified by Westerlund (*IAU Symp.* **20**, 239), are being studied photoelectrically and spectroscopically by Olander, Richer and Westerlund.

Carbon stars in some of the globular clusters in the SMC have been discussed by Feast (12.122.102; 11.122.117) and by Feast and Evans (10.114.032). They have $M_v \sim -3$ mag.

A catalogue listing 625 Hα emission-line objects in a 5° square area of the LMC has been prepared by Bohannan and Epps (12.159.002). A special publication of 'The Armagh Survey of Hα Emission Objects in the Large Magellanic Cloud', giving finding charts for 800 stars, has recently been made available by Andrews, Lindsay and Mc Farland. Individual stars, analysed in detail are HD 33579 (12.114.079) and HD 7583 (10.064.039), both previously studied for abundances. Fry and Aller (*Astrophys. J. Suppl.* No. 275) have analysed HR 8752, in the Galaxy, and R 59 in the LMC. They conclude that these G-type supergiants are similar in composition to the Sun, although in the LMC star metals are definitely under-abundant.

IV. *Variable Stars*

A number of lists of new variable stars in the SMC and LMC have appeared (11.123.001;

12.123.017; 12.123.035; Hodge and Wright, *Astron. J.* in press, Butler and Wayman, *Dunsink Obs. Publ.* I, No. 7). A summary of the distribution of variables in the Clouds has been given by Gaposchkin (09.159.006).

(a) A study of the intrinsic properties of *Cepheids* in the Galaxy, M 31, LMC and SMC has been presented by Iben and Tuggle (*Astrophys. J.* **197**, 39). They find all slopes in the mass-luminosity relation to be consistent with the theoretical evolution theory. The distance moduli found for the Clouds are essentially the same as found by other means. The metal contents decreases through M 31, LMC and SMC.

Feast (12.122.043) has investigated the fact that the long-period cepheids in the Clouds are too red for these spectral types. If this is due to absorption, then the cepheids with $P > 100$ days are about 1 mag. brighter than previously supposed and the mean period-luminosity relation does not flatten out at the long period end.

UBV photometry for 15 cepheids in the SMC and 22 in the LMC has been obtained by Madore (*Astrophys. J. Suppl.* **29**, 219). Demers (10.122.003) observed cepheids in 3 red globular clusters in the LMC, finding that their mean colours were comparable to those of Classical Cepheids and not to Population II Cepheids.

(b) Summaries of work on the *RR Lyrae variables* in the Clouds may be found in (11.122.130), (11.159.000) and (12.122.103). Light curves have been determined for 10 RR Lyrae variables in NGC 1466 (10.122.060) and for 18 in NGC 1835 (11.122.060) in the LMC.

Graham has an extensive investigation on the RR Lyrae variables in a 1.3 square degrees field, centered on NGC 121, in the SMC in press (*Publ. Astron. Soc. Pacific*) and a similar study of a field centered on NGC 1783 in the LMC well under way. 75 of the variables in the first field are RR Lyrae variables belonging to the SMC; with a distance modulus of $m - M = 19$ mag. their mean absolute visual magnitude is $+0.6 \pm 0.25$ mag. The period distribution is unlike that found anywhere in the Galaxy and resembles most closely that of the variables in the Leo II dwarf galaxy. There is some evidence that, for a given period, the SMC variables tend to have smaller amplitudes than galactic RR Lyrae stars.

Extensive searches for field RR Lyrae stars in both Clouds are being undertaken (cf. Geyer, *IAU Symp.* **67**, 557).

(c) A *nova* was discovered in the SMC (12.124.022) on 1974, August 19, about 4 mag. down from its maximum.

(d) Feast and Webster have described the spectra of some *VV Cephei* and *symbiotic* stars in the Clouds (12.121.013). The cool components of the VV Cephei systems in the LMC have $M_v \sim -7$; for the two symbiotic stars M_v is fainter than -3.4 and -1.5, respectively ($m - M = 18.7$).

(e) The variability of some *supergiant stars* has been investigated. Van Genderen has found evidence for a periodicity of about 90 days for HD 33579 (11.122.107), Appenzeller has confirmed light variations on time scales of a few hours for S Dor and HD 37836 (11.122.089). Thackeray shows that S Dor has recovered from a deep minimum, lasting 10 yr, and describes HDE 269006 as a new but hotter instance of variation of S Dor type. These stars have $M_v \sim -9.4$ at maxima (12.114.003). Also Wolf (*Astron. Astrophys.*, in press) has observed HDE 269006 photometrically and spectroscopically finding short term variations on a time scale of a few hours as well as a monotonously increasing brightness (during 23 days).

V. *Clusters and Associations*

A review of the completeness of the searches for clusters in both Clouds has been given by Hodge (*Irish Astron. J.*, in press, see also 11.154.026). If we include the clusters recently identified on plates taken with the 48-in. Schmidt telescope in Australia (Brück, *Monthly Notices Roy. Astron. Soc.*, in press) about 400 clusters appear to be known in the SMC; in the LMC the number is over 1600. An Atlas of clusters in the Clouds has been prepared by Alcaïno (*Astron. Astrophys. Suppl.*); it gives basic data for 162 clusters in the LMC and 116 in the SMC plus a total of 64 photoelectric sequences in the Clouds.

Colour-magnitude diagrams have been obtained for a number of clusters in both Clouds (10.154.015; 10.159.001; 11.159.001; Flower and Hodge, *Astrophys. J.*, **196**, 369, Hesser, Hartwick and Uqarte, submitted to *Astrophys. J. Suppl.*) It is of interest to note that Walker, in the continuation of his electronographic studies of $c - m$ arrays of globulars to very faint limits,

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derived a distance modulus $(m - M)_0$ = 18.05 ±0.10 for NGC 1866 (12.154.008). This value is in agreement with that derived by Divan for the LMC using BCD classification (10.115.019) but smaller than those obtained by other techniques (cf. 11.159.002).

The distribution of the clusters in the SMC shows a conspicuous central non-uniformity, an elliptical main body, an extension toward the SMC wing and a general radial exponential decrease similar to that for the brightest stars (12.153.004).

The analysis of the evolution of the cluster system in the LMC initiated by Hodge (10.159.007) has been continued. Six of the 10 clusters in an area of 0.5 square degrees in the eastern part of the LMC are found to have the same age (12.159.010); the remaining four are probably only a few million years older.

Hagen and van den Bergh (11.065.097) have compared the evolutionary tracks of massive stars in the Galaxy and in the Clouds by using colour-magnitude diagrams for the young clusters. They conclude that the SMC differs systematically from the Galaxy with the LMC in a intermediate position. Robertson (12.153.002) has compared the $c - m$ diagrams of 7 LMC clusters with theoretical sequences. Generally, observations and theory agree well. Too many blue stars are observed above the main sequence than predicted; it is suggested that most of them are binaries, which have undergone mass exchange.

Lucke has presented photographic B, V photometry for 4661 stars in 96 OB associations in the LMC (12.152.003) and given detailed analysis of the $c - m$ diagrams.

Borgman, van Duinen and Koornneef (*Astron. Astrophys.* **40**, 461) have carried out 5 colour photometry in the ultraviolet (1550 Å–3295 Å) of associations near 30 Dor. They conclude that the extinction law in the LMC differs from the average law in the solar neighbourhood; in particular the bump at 2200 Å is not present. However, it should be noted that this bump may not be a general feature in the Galaxy (12.113.031).

Photometry of the integrated light of clusters in the Clouds have been obtained by Danziger (09.154.010) in an 11-colour system. Bernard and Bigay (11.153.025) and Bernard (*Atron. Astrophys.* **40**, 199 and in press) have used the *UBV* and *uvby* systems. Among the quantities studied is the metal content of the evolved systems. Danziger's data have been further analysed by Heckmann (12.154.010) who found that the masses of the LMC globulars are 2 to 3 times smaller than those of old galactic globulars. All 7 LMC clusters analysed are found to be redder in integrated light than theory predicts, the opposite applies to the only SMC cluster studied.

VI. *H II Regions and Planetary Nebulae*

The chemical composition of H II regions in the Clouds have been investigated by Peimbert and Torres-Peimbert (12.159.007) and Dufour (*Astrophys. J.* **195**, 315). The former find a He deficiency of about 20 percent in the LMC H II regions as compared with the Orion and Carina nebulae; Dufour finds the He/H ratio to be the same in the LMC, SMC and nearby galactic H II regions. The heavy elements are somewhat under-abundant in the H II regions in the Clouds, among the elements N is most under-abundant. Spinrad has concluded from these data and others that in the SMC the overall metal abundance is about $\frac{1}{5}$ solar (*IAU Symp.* **72**).

From observations of H 109α and He 109α Huchtmeister and Churchwell (12.159.005) find for the 30 Dor nebula a He abundance more or less in agreement with those found in galactic H II regions.

Also McGee *et al.* (12.159.008) have studied the 109α recombination lines in the LMC and detected 8 sources and confirm for 30 Doradus a normal He/H ratio.

We note that a 100μ source has been seen in the direction of 30 Dor (09.155.039).

Broten (11.159.005) has estimated that the ionized hydrogen mass is about 15% to 20% of the total mass of the Clouds. However, the mass contained in the stronger ionized hydrogen regions is less than 1% of the total mass.

Osmer (*Astrophys, J,*, in press) finds from photoelectric observations of 3 planetary nebulae in each Cloud (1) a 40% over-abundance of He in all 6 nebulae; (2) a deficiency of a factor of 10 in O in the SMC nebulae; and (3) N/O ratios similar to those of galactic planetaries.

VII. *Dust*

The two Clouds have been searched for well defined dark nebulae by Hodge (08.159.001;

11.131.136) and van den Bergh (12.159.006), the resulting identifications agree well. The more general distribution of dust in the SMC has been discussed by Hodge (12.159.003, see also *Astron. J.*, **80**, 9) and by MacGillivray (*Monthly Notices Roy. Astron. Soc.* **170**, 241) using galaxy counts. Hodge concludes that the dust is distributed similarly to H I and that the ratio of neutral hydrogen mass to dust mass is about 300. MacGillivray confirms Hodge's results but notes in addition several regions of high absorption. Proof for a normal dust content in the core of the SMC has been provided by Martin and Thackeray (09.159.001).

Isserstedt (*Atron. Astrophys.* **41**, 175) has studied the distribution of dust in the LMC and concluded that it is similar to that of H I. He and Schmidt-Kaler (*Astron. Astrophys.* **41**, 241) have analysed the ratio N (H I)/E_{B-V} and found it in excellent agreement with the ratio derived in our Galaxy.

Polarization data have been discussed by Schmidt (12.131.215) and Visvanathan (12.158.190) and a model for the Magnetic Field of the Magellanic system has been presented (Deinzer and Schmidt 10.159.002) as time dependent.

C. *The Structure of the Magellanic Clouds*

21-cm H I observations (10.159.009) have confirmed the brighter structure discovered by Hindman, but Hindman's expanding shells have been found to have non-spherical motions. An anomalous cloud of H I has been found 8° from the centre along the major axis of the SMC.

The rotation and mass of the LMC have been investigated by Prévot (10.159.004) who found the major axis in position angle 180° in close agreement with previous results. Using previously determined data for rotation centre and tilt (27°) he obtains as total mass 0.48 x 10 $\mathfrak{M}_\odot$.

Isserstedt (*Astron. Astrophys.* **41**, 21) has analysed the structure of the LMC using the most luminous supergiants and concluded that they form long filaments (2–3 kpc x 0.4 kpc). He finds further that the western side of the LMC is nearer to us than the eastern one and, accepting a spiral structure in the LMC, that the LMC rotates with leading spiral filaments.

Ardeberg (*Astron. Astrophys.*, in press) using a similar material concludes that the super luminous stars are formed almost exclusively in super-associations. He concludes from data on supergiants and clusters that star formation during the last 2 x 10^7 yr has occurred mainly in one burst. Neither the structure nor the star-formation processes speak in favour of a spiral-structure type generation of stars.

A comparison between Cepheids and clusters made Payne-Gaposchkin conclude that star formation has taken place at different times in different parts of the LMC (09.065.120).

D. *The Magellanic Stream*

A southern sky survey in H I in the velocity range −340 to +380 km s^{-1} by Mathewson *et al.* (11.159.004) revealed a long filament extending from the region between the Magellanic Clouds to the South Galactic Pole and connecting to the long H I filament previously known. It may have been produced by gravitational interaction between the SMC and the Galaxy some 5 x 10^8 yr ago during a close passage of the SMC (20 kpc). Other data make this rather doubtful. A review covering the high-velocity neutral hydrogen clouds has been presented by Davies (12.155.067). A possible new segment of the Magellanic Stream in the northern sky has been announced by Cohen and Davies (*Monthly Notices Roy. Astron. Soc.* **170**, 23 P.); another cloud could be connected to it but more likely to M 31 (Davies, *Monthly Notices Roy. Astron. Soc.* **170**, 45 P.). Corwin and de Vaucouleurs (*Astrophys. J.*, in press) have shown that the Magellanic Stream and the H I high-velocity clouds are in the plane of the *Local Cloud* of galaxies inclined 14° to the main supergalactic plane.

We note in this connection that Keenan and Innanen (11.155.024) in studying the orbit of the old open cluster NGC 2420 proposed that its eccentric orbit and age may be reconciled as the result of a gravitational perturbation by an encounter with one of the Magellanic Clouds.

E. *Magellanic Irregulars*

We conclude by noting that the de Vaucouleurs (private communication) for the Revision of the Reference Catalogue on Galaxies have reduced to uniform systems all data on Magellanic irregulars, including types, *isophotal* diameters, axis ratios, *total B* magnitudes and $U-B$, $B-V$ colours, red shifts, continuum fluxes at 1400 MHz and 21 cm line fluxes.

Many Magellanic-type systems are being studied by them and their colleagues, we refer here only to NGC 1569 (12.158.183).

7. WORKING GROUP ON GALAXY PHOTOMETRY AND SPECTROPHOTOMETRY

(H. D. Ables)

Following the precedent set by G. de Vaucouleurs in his 1970 report, we have summarized the galaxy photometry and spectrophotometry in the following table. This summary does not include work in the U.S.S.R. or work published in U.S.S.R. journals. From the number of entries in the table it is clear that the fields of galaxy photometry and spectrophotometry are alive and well troughout the world.

During the report period a request was made to the members of the working group that NGC 3379 be adopted as the standard galaxy for photometric comparisons. All members were encouraged to measure the east-west *B* luminosity distribution through the well-defined nucleus of NGC 3379 so that a 'standard' luminosity profile can be established. G. de Vaucouleurs and M. Capaccioli have completed and will soon publish a detailed study of this luminosity distribution over a range in surface brightness of 14 to 28 mag. arc sec^{-2}. This study includes a detailed quantitative analysis of limiting factors in the precision photometry of E galaxies.

A major coming attraction is the second and greatly expanded edition of the *Reference Catalogue of Bright Galaxies* which is being prepared for publication in 1976 by G. and A. de Vaucouleurs and Colleagues.

Summary of Galaxy Photometry and Spectrophotometry 1973–75

Authors	Subject	Type*	References
Oke and Tovmassian	Markarian 205	B, pe	09.158.002
Arp and Brueckel	H II regions in M 31 and M 33	D, pg	09.158.013
Robinson and Wampler	Ton 524a, b	B, pe	09.158.016
Heeschen	12 E galaxies	E, pe	09.158.019
Kinman	M 87	E, pe	09.158.020
Collin-Souffrin *et al.*	NGC 3516	B, pg	09.158.023
Faber	31 E galaxies	B, pe	09.158.027
Hall and Usher	I Zw 187	A, pg	09.158.037
van Genderen	Absorbing material in M 31	A, pg	09.158.038
Spinrad *et al.*	Maffei 2	A, B, pg, pe	09.158.052
Sandage	12 N and 4 E galaxies	A, pe	09.158.055
Ables and Kron	M 87 jet	A, eg	09.158.059
King and Kiser	NGC 5846	C, pg	09.158.060
de Vaucouleurs	NGC 1566	C, pg	09.158.061
Disney	IC 4329A	A, B, pe, pg	09.158.107
de Vaucouleurs and Agüero	14 southern galaxies (comparison)	C, pg	09.158.108
Sakka *et al.*	NGC 2782	A, pe, pg	09.158.109
Kaneko *et al.*	M 87 jet	C, pg	09.158.110
Forrester	NGC 4670, 4747, A 1244	B, pg	09.158.111
Joly and Andrillat	M 31	B, pg	09.158.126
Schwarzschild	NGC 4151 nucleus	D, pg	09.158.141
Spinrad	NGC 5195	B, pe	09.158.144
Penston	M 31, 33, 51, 101, NGC 5195	A, pe	09.158.149

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Authors	Subject	Type*	References
Glass	NGC 7552, 7582, 7590	A, pe	09.158.150
Lynds *et al.*	NGC 4314	C, pg	09.158.156
Hodge	NGC 205	C, pg, pe	09.158.157
Tifft	26 galaxies in Virgo	A, pe	09.158.158
Danziger	Glob. cl. in Mag clouds and Fornax	B, pe	09.154.010
Weedman	92 Markarian and 5 Seyfert galaxies	A, pe	10.158.003
Sakka *et al.*	NGC 4670	A, B, pg	10.158.013
Sandage	Cluster galaxies	A, pe	10.158.018
Glass	27 southern galaxies	A, pe	10.158.023
Tifft	Nuclear magnitudes	A, pg	10.158.041
Burkhead and Burgess	NGC 1300	C, pe	10.158.042
Ptak and Staner	NGC 3516, 4151, 5548	B, F, pg	10.158.046
Benvenuti *et al.*	M 33	B, pg	10.158.069
Chromey	NGC 4753, 5273	B, pe, pg	10.158.077
Elvius	NGC 3067, 3718, 4216, 4438, 4565	E, pe	10.158.092
Chincarini and Heckathorn	NGC 523	C, eg	10.158.101
Warner	M 64	B, pg	10.158.102
Alloin and Andrillat	NGC 3504	B, pg	10.158.106
Lynds and Furenlid	NGC 7625	B, C, pg	10.158.111
Barbon and Capaccioli	NGC 3628	C, pg	10.158.146
Capaccioli	NGC 4258	C, pg	10.158.147
Schanberg	63 peculiar gal. and 28 multiple gal.	C, pg	10.158.150
Sandage	cluster galaxies	A, pe	10.160.006
Stein *et al.*	NGC 1068, 4151 (8–13 μ)	A, B, pe	11.158.005
Kron and Shane	589 galaxies	A, D, pe, pg	11.158.012
Chromey	NGC 3955, 4433	B, pe, pg	11.158.013
Alcaino	38 southern galaxies	A, pe	11.158.015
Weedman and Carswell	NGC 6207	A, B, pe, pg	11.158.017
Hodge and Smith	Fornax dwarf gal.	C, D, pe, pg	11.158.019
Netzer	NGC 3227, 4051, MARK 79	A, pg	11.158.029
Jameson *et al.*	NGC 1068	B, pe	11.158.034
Notni	265 compact galaxies	A, pg	11.158.039
Worden	M 51	C, pg	11.158.042
Osmer *et al.*	NGC 1566, 3783	A, B, pe, pg	11.158.062
Anderson	NGC 4151	C, pg	11.158.063
Holmberg	174 groups of gal.	A, pg	11.158.066
Warner	NGC 5195	B, pg	11.158.087
Carozzi *et al.*	14 compact galaxies	B, pg	11.158.098
Rose and Tinsley	Ellipticals	F, A, B	11.158.100
Comte, Monnet	NGC 598 (M 33)	B, pg	11.158.104
Joly	M 31	F, B	11.158.105
Kormendy and Bahcall	Field and cluster gal.	C, pg	11.158.114
Oka *et al.*	NGC 2903	A, B, pg	11.158.116
Wlerick *et al.*	BL Lacertae	C, eg	11.158.302
Tabara *et al.*	BL Lacertae	A, pg	11.158.303
Martin	NGC 1068, 1566, 3783, 6814, 7649, IC 4329A	B, pg	12.158.002
Alloin and Sareyan	NGC 55, 253, 1068, 1084, 1097, 1566, 6822, 7469, 7496, 7552, IC 4662	B, pe, pg	12.158.003
Burkhead and Kalinowski	NGC 3379, 3384, 3389	C, pe	12.158.028
Knacke and Capps	NGC 1068	E, pe	12.158.043
Kron and Shane	Lick Survey gal.	A, D, pe, pg	12.158.044
Osmer *et al.*	NGC 613, 1097, 1365, 1672 1808, 2992, 2997, 5253	B, pe	12.158.064

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Larsen and Tinsley	Elliptical galaxies	F, A, B	12.158.065
Visvanathan	M 82	E, B, pe	12.158.067
Dottori	24 Virgo cluster gal.	A, C, pg	12.158.099
Penston *et al.*	NGC 1068, 1275, 2782, 3227 3516, 4051, 4151, 5548, 6814, 7469, 3C120	A, pe, pg	12.158.102
O'Connell	NGC 3998, 4374, 4459, 4472, 4552	B, pe	12.158.111
Hartwick and McClure	Draco dwarf galaxy	B, pe	12.158.114
Shields	Spirals	F, B	12.158.115
Kinman *et al.*	M 87 jet	A, pe	12.158.124
Chromey	NGC 3067, 3077, 4691	B, pe	12.158.144
Boulesteix *et al.*	M 33 H II regions	D, pg	12.158.145
Joly	NGC 3031	B, F	12.158.146
Light *et al.*	M 31	D, pg	12.158.148
Beaver	Arp 295	A, pe	12.158.151
Walker *et al.*	NGC 4319, Mark. 205, Seyfert's Sextet, NGC 7063 and comparison	C, eg	12.158.184
de Vaucouleurs and de Vaucouleurs	Seyfert Galaxies	F, A, C	12.158.191
Walker	M 31 nucleus	D, eg, pg	12.158.195
Walker *et al.*	3C120	C, eg	12.141.133
Kormendy and Sargant	NGC 68	C, pg, pe	12.160.022
Weedman	72 Coma and 44 Perseus cl. gal.	A, pe	*Astrophys. J.* **195**, 587
Grasdalen	28 galaxies	A, pe	*Astrophys. J.* **195**. 605
Shields and Oke	NGC 1068	B, pe	*Astrophys. J.* **197**, 5
Rieke and Low	NGC 253	B, C, pe	*Astrophys. J.* **197**, 17
Oke and Schwarzschild	M 31, M 32	B, pe	*Astrophys. J.* **198**, 63
Freeman *et al.*	NGC 253	C, pg	*Astrophys. J.* **198**, 93
Smith	12 nearby S and Irr. gal.	B, pg	*Astrophys. J.* **199**, 591
Davis	NGC 3987, 5907	C, pe	*Astron. J.* **80**, 188
Simkin	NGC 2683, 4192, 4216,5746	C, pg, pe	*Astron. J.* **80**, 415
Krienke Jr.	NGC 520	C, pe, pg	*Astron. J.* **80**, 492
de Vaucouleurs	NGC 1291	C, pg, pe	*Astrophys. J. Suppl.* **29**, 193
Barbon *et al.*	NGC 3384	C, pg	*Astron. Astrophys.* **38**, 315
Comte	M 33, M 51, M 101	B, pg	*Astron. Astrophys.* **39**, 197
Segalovitz	M 81	F, A, C	*Astron. Astrophys.* **40**, 401
Benvenuti *et al.*	NGC 2146	B, C, pg	*Astron. Astrophys.* **41**, 91
Barbon and Capaccioli	NGC 1023	C, pg	*Astron. Astrophys.* **42**, 103
Collin-Souffrin and Andrillat	NGC 3310	B	To be published
Collin-Souffrin and Andrillat	Seyfert galaxies	B	To be published
Vandekerkhove		F, A, B	*Bull. Classe Sci. Acad.* Roy. Belg. 1973, p. 884
Vanderkerkhove	Brt. galaxies	F, B	*Bull. Classe Sci. Acad. Roy. Belg.* 1973, p. 884
Vanderkerkhove	Brt. galaxies	B	To be published
Richter and Höyner	Coma cluster	C	*Astron. Nachr.* **296**, 221
Osterbrock and Miller	3C405 = Cyg A	B, pe	*Astrophys. J.* **197**, 535
Alcaino	35 southern gal.	A, pe	To be published
Paal	Galaxies in rich clusters	D, pg	*IAU Symp.* **63**
Paturel	Catalog galaxies	D	*Astron. Astrophys.* **40**, 133
Barbon and Capaccioli	NGC 2683	C, pg	To be published
Bergvall	Compact galaxies	A, pe	In progress
Kinnander	Compact galaxies	A, B, pg	In progress
Gunn and Oke	Large redshift gal. in clusters	B, pe	*Astrophys. J.* **195**, 255

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Authors	Subject	Type*	References
Tsikoudi	NGC 3115, 4111, 4762	C, pg	In progress
Maza	NGC 2442-3	C, pg	Unpublished
Hodge	NGC 147	C, pg, pe	To be published
Hodge and Steidl	NGC 524	C, pg, pe	To be published
Crane	NGC 2950	C, pe	To be published
Schweizer	NGC 3031, 4254, 4321, 5194, 5364, 5457	C, pg, pe	To be published
Ables and Ables	A 2359	C, pg, pe, eg	To be published

*Type. – A = general broad-band photom., etc., magnitudes and/or colors; B = intermediate band photom., energy distribution, spectral indices, line-strengths; C = detailed surface photom., isophotom., drift curves; D = photometric diameters and other special studies; E = polarization; F = theoretical.

8. WORKING GROUP ON INTERNAL MOTIONS IN GALAXIES

(P. Pişmiş)

Substantial amount of work has been done in the field of internal velocities in galaxies since the last report of Commission 28, both in the optical and in the radio range. In general, masses and mass to light ratios are derived from the data.

A very important and useful contribution to the workers on galaxies is the comprehensive 'Bibliography on the Structure of Galaxies' by Brosche, Einasto and Rümmel (*Veroeffentl. Astron. Rechen-Inst. Heidelberg,* No. 26). Among a wealth of information on galaxies, kinematical data are also given.

In a review on the rotation curves of galaxies Roberts (*IAU Symp.* **69**, 331) concludes that the rotation curves from 21-cm data, which extend farther than the optical data, show, essentially, a flat maximum. More recent 21-cm observations of the southern end of M 31 (Roberts and Whitehurst, preprint) indicate that the rotation velocity is essentially constant from 20 to 30 kpc. Such a tendency is detected in several other galaxies mentioned in what follows.

From an aperture synthesis study of neutral hydrogen it is shown that the rotation curves remain rather constant after reaching their maximal velocity, in the galaxies NGC 6946, IC 342 by Rogstad *et al.* (09.158.005) and in NGC 2403 by Rogstad and Shostak (09.158.086), while NGC 4236 exhibits solid body rotation over the length of the bar (09.158.086). In an investigation of the gross properties of five Scd galaxies (M 33, NGC 2403, IC 342, M 101, and NGC 6946) using the 21-cm line, Rogstad and Shostak (08.158.032) find substantial similarities in the hydrogen distribution and rotation curves of these galaxies.

Neutral hydrogen surveys by Huchtmeier have yielded velocity fields in NGC 3109 (09.158.003), M 33 (09.158.004) and NGC 4244 (09.158.025). Significant departures from circular motion are detected only in the irregular galaxy NGC 3109.

The velocity field in NGC 5236 (M 83) has been investigated from the 21-cm line by Bottinelli and Gouguenheim (10.158.118). The kinematic major axis of the galaxy varies as one considers more and more external regions; non-circular motions are thus superposed on a circular one. A high resolution (2′ synthesis) neutral hydrogen study carried out by Gottesman and Weliachew (*Astrophys. J.* **195**, 23) has yielded a rotation curve for M 81. The disk of this galaxy shows strong non-circular motion in the vicinity of the satellite, DDO 66/HoIX. The kinematics of M 81 does not show the systematic pattern of non-circular velocities expected from the density-wave theory.

A very detailed velocity field for M 31 is derived by Deharveng and Pellet (*Astron. Astrophys.* **38**, 15) using essentially the photographic Fabry-Pérot technique. No expansion is detected in the nucleus; the N arm exhibits a wavy rotation. On the other hand Rubin *et al.* (09.158.063) from the study of an absorption feature conclude that stellar velocities in the nucleus of M 31 resemble the gas motions. Excess positive velocities are observed where gas is observed streaming out from the nucleus. Whitehurst and Roberts (08.158.008) report to have detected a negative high velocity neutral hydrogen feature in the central region of M 31.

By the use of a pressurized Fabry-Pérot interferometer Tully (11.158.131.132.133) has studied the velocity field of M 51 photographically and in great detail; the non-circular velocities are not as large as previously found by other authors, presumably due to the deconvolution procedure applied by Tully. A high resolution neutral hydrogen study of the galaxy M 51 carried out by Weliachew and Gottesman (09.158.039) shows that the velocities in the spiral arm facing the companion are strongly non-circular, as predicted by tidal interaction. Van der Kruit has derived rotation curves from slit spectra of NGC 4321 (10.158.145) and of the infrared spiral galaxy NGC 3675 (*Astrophys. J.* **195**, 611); the latter does not show a strong non-circular motion.

Aperture synthesis observations at 21-cm have shown that Maffei 2 is a rotating early type galaxy (Wright and Seielstad, 09.158.001). Carozzi (submitted to *Astron. Astrophys.*) has obtained a rotation curve of the Sc galaxy NGC 6015 from image tube spectrograms taken with the 193-cm telescope of Haute Provence Observatory. A rotation curve past the maximum is derived for the late-type galaxy NGC 1313 using the Fabry-Pérot technique by Carranza and Agüero (11.158.026); a more detailed study of the velocity field is under way.

It is interesting to note that velocities in galaxies based on their stellar component are being investigated as of late; Simkin (*Astrophys. J.* **195**, 293) has given a discussion of the velocity field of NGC 2903 from observations of the stars and the gas. The large non-circular velocities and radial streaming motions found both in the gas and stars seem to be associated with the spiral arms. Bertola and Capaccioli (preprint) using the 5-m telescope obtain a rotation curve from H and K absorption lines of the elliptical NGC 4697; the angular momentum of the galaxy is shown to be lower than for a spiral of comparable mass. Again from absorption lines Williams (*Astrophys. J.* **199**, 586) derives for NGC 3115 a rotation curve which rises to 260 km s^{-1} at 25″ from the center and remains constant to 100″.

An important step is taken by Duval-Cheriguene in initiating with the Haute Provence 2-m telescope a systematic survey of the velocity fields of barred spirals of all types; the preliminary results on the rotation curves of the following barred galaxies, of a range in types, were presented at the CNRS International Colloquium on the Dynamics of Spiral Galaxies held at the Institut des Hautes Etudes Scientifiques, Bures sur Yvette, France, 16–20 September, 1974: NGC 2146, 2366, 3198, 3319, 3359, 3556, 4214, 4631, 4656, 5204, 5383 and LMC. At the third European Regional IAU Meeting held in Tbilisi, 1975, further results on NGC 2146 and NGC 5383 were presented. The preliminary results suggest an evolution in the rotation curves as a function of morphological type. Rubin *et al.* (*Astrophys. J.* **199**, 39) obtain radial velocities in the barred spiral NGC 3351; they suggest that there is evidence for contraction in the nuclear ring of that galaxy.

In a series of papers Morton and collaborators have derived stellar velocity dispersions at the nucleus of the following galaxies: NGC 1889 (E0) 3115 (E7/SO), 4473(E5) and 4494 (E1) (Morton and Chevalier 09.158.008) obtaining σ = 110, 215, 160 and 160 km s^{-1}, respectively. In M 31 σ = 120 km s^{-1} is derived (Morton and Thuan 09.158.056). Recently Morton and Elmergreen (preprint) give for the velocity dispersion of M 31 and M 32 the values 130 and 55 km s^{-1} respectively. A study of the nucleus M 32 by Richstone and Sargent (08.158.018) has yielded σ = 65 km s^{-1}, smaller than the previously obtained value of 100 km s^{-1}.

It is gratifying to witness the initiation of investigations on galaxies jointly by optical and radio astronomers. The rotation curve of the peculiar galaxy NGC 4861 has been obtained by Carozzi *et al.* (11.158.003) at Haute Provence Observatory in a joint optical and radio study.

Quite a few irregular, peculiar, interacting galaxies have been investigated. In an interferometer study of Centaurus A (NGC 5128) Wright (*Astron. Astrophys.* **31**, 283) reaches the conclusion that the H I absorption feature discovered earlier by Roberts is probably similar to the phenomenon of high velocity clouds in our Galaxy. Data obtained from an aperture synthesis study of H I in IC 10 (irregular) are shown (Shostak, *Astron. Astrophys.* **31**, 97) to be consistent with a flattened gas distribution undergoing general rotation. Stockton (11.158.103) has derived rotation curves from the spectra of the two principal galaxies of the interacting system Arp 295; it is proposed that the bridge between the galaxies is of tidal origin.

Heckathorn has derived a detailed velocity field of the peculiar galaxy M 82 (07.158.109) by slit spectra. He concludes that the expanding cloud of ejecta is rotating about an axis perpendicular to the fundamental plane. In NGC 3077 a peculiar galaxy which resembles M 82 in having filaments and wide absorption regions, Barbieri *et al.* (*Astron. Astrophys.* **35**, 463) do not detect any rotation within 40″ of the center. As a result of a detailed study of the irregular galaxy NGC 5253 Sersic *et al.* (09.158.152) conclude that the galaxy has been the site of a violent event like that in M 82. Another galaxy proposed to be similar in behavior to M 82 is NGC 1569 which is shown by de Vaucouleurs *et al.* (*Astrophys. J.* **194**, L119) to have undergone a past eruption.

In optical studies of Ir II galaxies Chromey finds that NGC 3955 and NGC 4433 exhibit large scale non-circular motions (*Astron. Astrophys.* **31**, 165) while NGC 3067, NGC 3077 and NGC 4691 appear to have normal internal motions (*Astron. Astrophys.* **37**, 7). An interferometric study of 21-cm absorption by Gottesman *et al.* (preprint) reveals an excess of blue shifted velocities in the central radio core of NGC 253; neutral gas is thus moving towards the observer in confirmation to optical studies and unlike molecular features which are redshifted.

That the double galaxy NGC 7752–53 is an unstable system is concluded by Bertola and D'Odorico (09.158.046) on the basis of the derived velocity field of the main galaxy and the radial velocity of the companion. From a spectrum of the long tail of NGC 4676 A, a peculiar galaxy, Theys *et al.* (08.158.127) find that the radial velocity varies by about 400 km s^{-1} along the length of the tail.

As to Klemola 30, a group of four interconnected galaxies, Graham and Rubin (*Astrophys. J.* **183**, 19) on the basis of a spectrogram covering two of the galaxies infer that the dominant galaxy is moving with retrograde motion with respect to the second one. The optical study of the peculiar spiral, NGC 2146, by Benvenuti *et al.* (*Astron. Astrophys.* **41**, 91) shows only moderate nuclear activity; a rotation curve is derived.

Seyfert galaxies have been the subject of several investigations. M. H. Ulrich (08.158.108) with 8 spectra taken at differing position angles finds a rotating nucleus in NGC 1614 of 570 pc in radius and evidence of outflow of ionized gas from it. From image tube spectra taken at 11 different position angles across the nucleus of NGC 4151 Ulrich (09.158.062) concludes that there are essentially four gas clouds moving away from the center of the galaxy with velocities 200–300 km s^{-1}. An alternative interpretation is however suggested. Using the same observational material Anderson (11.158.033) argues that the motions in the nucleus of NGC 4151 are rotational rather than radial. From 8 image tube spectra Fricke and Reinhardt (*Astron. Astrophys.* **38**, 349) interpret the velocity field of the nucleus of NGC 4151 by a superposition of rotational and radial motions. Davies (09.158.010), from a neutral hydrogen study, obtains 26° for the position angle of the major axis of NGC 4151, and not the generally adopted value of 130°.

In a study of the Seyfert galaxy NGC 7469 (09.158.143) from high resolution spectrograms Anderson confirms his interpretation of Seyfert nuclei: that their velocity curves largely reflect the rotation of the galaxy. In NGC 6764 a barred galaxy, Rubin *et al.* (*Astrophys. J.* **199**, July 1) detect discrete cloud motions and suggest that the galaxy is a Seyfert. I 4329A, an extreme Seyfert galaxy, is shown by Disney (09.158.107) to have an Hα as wide as 13 000 km s^{-1}.

Substantial contribution towards an understanding of compact, Markarian and Haro galaxies has been made in the past years. O'Connell and Kraft (07.158.131) obtain, optically, a rotation curve for the compact galaxy I Zw 129 but find no evidence for unusual gas motions in this and in I Zw 70. Mass motions in the inner region of Markarian 78 are optically detected by Adams (09.158.012) who also has detected strong blue-shifted lines in absorption in the nucleus of Markarian 231 (08.158.019). From a spectroscopic investigation of Markarian 8 Khachikyan (09.158.131) concludes that the 5 super-associations comprising the galaxy have radial motions of 150–200 km s^{-1}. Several 21-cm line studies have shown that the velocity spread within a galaxy is related to the luminosity of the galaxy. Large luminous Markarian galaxies (Bottinelli *et al.*, 09.158.007) have large internal motions, while small and faint ones have small internal motions. On the other hand the dwarf irregular galaxies (which are characterized by a very low surface brightness) have small internal velocity dispersion, smaller than classical irregulars

(Balkowski *et al.*, *Astron. Astrophys.* **34**, 43). A further welcome case of collaboration between optical and radio astronomers is the study carried out on 9 non-Seyfert Markarian galaxies, spectroscopically at the Haute Provence Observatory and in the 21-cm line at Nançay (Bottinelli *et al.*, *Astron. Astrophys.* **41**, 61). It is confirmed that this class of Markarian galaxies do not constitute a homogeneous group. Seven of them are of morphological type ranging from spiral to irregular.

A great deal of new information on the internal velocity in galaxies is expected in the very near future. Dr G. de Vaucouleurs informs that with the McDonald 36-in. and 82-in. reflectors Hα Fabry-Pérot interferograms (usually several per object) are available on the following galaxies: NGC 45, 55, 247, 253, 925, 1156, 1507, 1569 (results on the latter are reported above), 1744, 2188, 2537, 3109, 4214, 4631, 5253, 6822 and 7793, IC 1727, 2233; A 2359. Low dispersion spectrograms ($4500 < \lambda < 8500$ Å; 180–360 Å mm^{-1}) have been obtained on NGC 178, 1326 A, 2552, 2799, 4633, 7764 and IC 2233. The spectrograms as well as the interferograms are in the process of reduction.

C. Wilson from the Hale Observatories informs that rotation curves are being measured, from absorption lines, on image tube spectra obtained with the 60-in. telescope. The dispersion is either 40 or 65 Å mm^{-1}, and the scale along the slit is 100″ mm^{-1}. All the spectra have been obtained with the slit along a galaxy's major axis. The objects observed so far are NGC 221, 2768, 3115, 3379, 4473, 4697, 5322 and 7332.

Also, a SIT vidicon is being used as a detector with the coudé spectrograph of the Mount Wilson 100-in. telescope. The dispersion is either 10 or 22 Å mm^{-1}, and the transverse scale 15″ mm^{-1}. The galaxy spectra obtained with this equipment will provide the central velocity dispersion and rotation over the inner few arcsec. Galaxies that have been observed are NGC 221, 224, 720, 3115, 3379, 4621 and 4697.

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