and G. R. Burbidge and K. H. Prendergast (**34**), examining the velocity distribution in NGC7479, showed that the bar is rotating as a solid body, but the falling off in velocity outside the bar is faster than the Keplerian curve, and indicates streaming motions in the outer arms. Various results were also obtained for NGC3504, NGC1365, NGC5383, often indicating non-circular velocities.

G. and A. de Vaucouleurs (**35**) with a prime-focus spectrograph on the 82-inch reflector of McDonald Observatory have made detailed observations of the late-type barred spirals NGC4631, 4027, and 7741 which indicate the presence of large-scale streaming motions of the interstellar gas away from the nucleus and along the bars; the streaming velocities are of the order of 50 to 100 km sec^{-1} (see IAU Symp. no. 20, p. 269).

A. E. Whitford (**31**) has obtained infra-red spectra of the nuclear regions of bright galaxies with a view to using the Sharpless stellar luminosity criteria in the region 7600–8800 Å as an indicator of the proportion of giant and dwarf contributions to the total light. On spectrograms at 200 Å/mm taken with the prime focus spectrograph of the 120-inch telescope of the Lick Observatory no certain trace of the Na I doublet at 8183–8195 Å could be seen for the galaxies M31, 32, 81, NGC2681, 3115, 4406. If contributions of dwarfs to the total light in the infra-red come from types earlier than M0 the lines would be weak and the observations put a limit on the amount of late-dwarf enrichment to account for a mass-luminosity ratio of 15 or more.

D. B. Wood of the Berkeley Astronomy Department measured 22 galaxies through 12 narrowband filters. The Mgb triplet was found to be a sensitive feature. Synthesis of stellar population to match the photometric data showed that dwarf K stars are important contributors to the total visual light, expecially in massive systems.

From photo-electric spectrophotometry of the nucleus of M31 with the 74-inch telescope of the David Dunlap Observatory, S. van den Bergh and R. C. Henry (**36**) confirm Morgan's conclusion that metal-rich cyanogen giants yield a substantial contribution to the total luminosity of the nucleus in blue light.

Van den Bergh has used the 52-inch Schmidt of the Karl-Schwarzschild Observatory to obtain plates in five colours of the galaxies M31 and M33, in order to study the distribution of bright young stars and their relation to the spiral structure. The limiting magnitude of the blue plates is 21·7. Descriptions and finding charts for 188 OB associations in M31 are being prepared.

V. C. Reddish (**38**) has investigated the distribution of bright stars in M31 in relation to the phenomena of obscuration in the system.

In this connection special attention should be drawn to the importance of following up recent enlargements and modifications of Hubble's system of classification, though this system in its classical form remains of paramount importance as basis for investigations on galaxies. A modification introduced by Morgan (**39**) is based on the spectroscopic work on composite spectra of galaxies by Morgan and Mayall, and is intended to be indicative of the general kind of stellar population encountered in the majority of galaxies classified. G. de Vaucouleurs (**40**) has introduced a modified system in which an important point is that in the types discrimination is made between 'ring types' and 'spiral types'. Revised types in this system have been published for 1500 bright galaxies (**50**).

REPORT ON THE ACTIVITIES SINCE AUGUST 1961 OF THE COMMITTEE FOR RESEARCH ON SUPER-NOVAE

(prepared by F. Zwicky, Chairman)

At the Assembly of the IAU in Berkeley in August 1961 a Committee for Research on Super-novae was established within Commission 28. The original members of the Committee were as follows.

Ch. Bertaud	(Meudon, France)
E. F. Carpenter	(Tucson, Arizona, U.S.A.)
G. Haro	(Tonantzintla, Mexico)
B. V. Kukarkin	(Moscow, U.S.S.R.)
L. Rosino	(Asiago, Italy)
J. L. Sérsic	(Cordoba, Argentina)
P. Wild	(Berne, Switzerland)
F. Zwicky, Chairman	(Pasadena, California, U.S.A.)

The observatories which so far have co-operated in the search program are Asiago in Italy, Abastumani, Burakan and Crimea in the U.S.S.R., Cordoba in Argentina, Meudon in France, Palomar, Lick and Tucson in the U.S.A., Tonantzintla in Mexico and Zimmerwald (Berne) in Switzerland. Co-operation has also been offered in the fall of 1961 by Dr E. Vandekerkhove of the Royal Belgium Observatory at Uccle (Brussels) and most recently by Dr Lambrecht, Jena Observatory, which we are happy to accept.

Goals of the search for Super-novae

At Berkeley, the Committee set itself the following goals.

1. Organisation of the search for super-novae on an international scale.
2. Follow up, as far as possible of all objects discovered through observations of their spectra and of their light curves, as well as the study of the structural and spectral characteristics of their parent galaxies.
3. Establishment of contacts with radio astronomers and cosmic ray observers in order to establish at what stage of development super-novae emit radio waves and cosmic rays. Also study of the remnants of super-novae.

In the intervening two years task one has been most successfully accomplished and 42 super-novae have been discovered in the period from August 1961 to October 1963. All of these discoveries were made by members of our committee or by some of their direct associates. This brings the total of all super-novae discovered since 1885 to 140.

As to the tasks two and three an excellent beginning has been made. Actually, spectra of most of the 42 super-novae discovered have been observed. Also, spectra of a majority of the parent galaxies have been recorded. It will, however. be necessary to observe the spectra at various intervals after the eruption of a super-nova, a program which we hope to organize more firmly at the Hamburg meeting.

Data on the light curves of many of the super-novae found are also available which will have to be collected from all of the observers. The light curves of about half the number of super-novae discovered during the past three years have been published or are in the course of publication.

Areas searched and super-novae found

Most of the participating observatories have been searching for super-novae in galaxies brighter than the fifteenth apparent magnitude. As Dr B. V. Kukarkin states it in his report to the Committee 'The search in the U.S.S.R. is aimed at the early discovery of bright super-novae and at their study in the greatest possible detail'. Kukarkin's group therefore essentially searches only in four restricted areas of the north galactic cap, notably around the center of the Virgo cluster and other areas which contain many bright galaxies. Two bright super-novae were discovered during this program by N. E. Kuročkin in IC3112 and by G. V. Zaitsewa in NGC4178. Other members of the committee have worked on similar lines, using Schmidt telescopes from 30-cm to 60-cm aperture or, in some cases, astrographs (Crimea and Tucson).

At Asiago, about 36 fields covering 30 square degrees each were searched as often as possible

and four bright super-novae were discovered by L. Rosino in NGC4382, E. Romano in NGC4564, L. Rosino in NGC1073 and 4146. Also, a peculiar object was observed flaring up on the outskirts of NGC4501 (Messier 88). This object, however, is most likely a recurring common nova or some peculiar flare variable in our own Galaxy.

At Zimmerwald (Berne), P. Wild, because of much cloudy weather, has searched in various areas in a more or less random fashion. This search was nevertheless remarkably successful, inasmuch as he discovered the most interesting super-nova of type V just prior to the Berkeley meeting and subsequently found those in the Anon Sc spiral at R.A. $2^h32^m30^s$ and Decl. $+37^\circ\ 25'$ (1950) and in NGC3221, 3938, 6835, 5905 and 1084, as well as, independently after Zwicky, the super-nova of type I in NGC3913.

G. Haro and E. Chavira at Tonantzintla found the super-novae in IC4237 and independently of Rosino the one in NGC1073.

Ch. Bertaud at Meudon discovered a super-nova in NGC3656 and J. L. Sérsic found the beautiful super-nova in NGC1313. This is probably the apparently brightest super-nova since the one found by Zwicky in IC4182 in 1937. As ill luck would have it, NGC1313 is at Decl. $-66^\circ\ 40'$ and can only be followed by a few of our colleagues on the southern hemisphere. Thackeray reports that spectra obtained at 80Å/mm (at Hγ) on 1962 December 6, 9 and 19, indicate that the super-nova is of type II with H absorption displaced by several thousand kilometers per second from the emission bands. The star at maximum was probably brighter than $m_p = 10$.

At Palomar, with the 18-inch Schmidt in spite of heavy coverage of many fields by H. S. Gates, only one super-nova was discovered accidentally by Zwicky in NGC3913. It was of type I.

With the 48-inch Schmidt at Palomar about thirty fields of 16 square degrees each were searched as often as possible. These fields include the central parts of several large clusters in Cancer, Coma, Corona Borealis, the latter one being the most distant so far watched. Since August 1961, 29 super-novae were discovered with the 48-inch Schmidt by J. Berger (2), H. S. Gates (2), M. L. Humason (4), C. E. Kearns (1), C. Kowal (1), Mrs M. Mendez (1), G. Reaves (3), K. Rudnicki (2) and F. Zwicky (13). Among these objects four were in the Coma cluster and one in the Corona Borealis cluster.

Basic results achieved

1. Super-novae were found in giant galaxies (luminosity $L > 10^8\,L_\odot$), in medium galaxies ($10^8\,L_\odot > L > 10^6\,L_\odot$) and in dwarf galaxies ($10^6\,L_\odot > L > 10^4\,L_\odot$). No super-nova has as yet been discovered in any Pygmy galaxy ($10^4\,L_\odot > L > 10^2\,L_\odot$) or in any small group of intergalactic stars or in intergalactic space.
2. The structural types of the galaxies in which the 140 super-novae known since 1885 have appeared are of such an astonishing variety that one begins to wonder whether the Hubble classification of galaxies has a sufficiently universal meaning.
3. At least five types of super-novae have been found, as judged from their spectral characteristics (and to some extent from their light curves). These spectral characteristics are described in the reviewing article by F. Zwicky (manuscript March 1962) which is to appear in the monograph on 'Stellar Structure', Volume 8 of the Compendium of astronomy and astrophysics *Stars and Stellar Systems*, edited by G. Kuiper and B. Middlehurst, published by the University of Chicago Press.
4. The spectra of most of the super-novae discovered recently and of their parent galaxies have been studied and a great number of new features have been found. In particular, it appears from some spectra obtained by Zwicky in fast succession that there are sharp features superposed on the bands of the super-novae of type I. These features persist for a few hours

or for a few days and may furnish the long sought for clues to the interpretation of the now entirely mysterious spectra of super-novae of type I.

5. More or less complete light curves will be available for most of the super-novae recently discovered once all of the material from the various observatories can be gathered. The light curves, however, have proved far less significant than was thought originally. In particular, type II super-novae, with entirely different spectra from those of type I, may have light curves which are so far indistinguishable from those of type I. Also it has been found that the supposedly linear decay of the light curves of super-novae of type I in later stages of their development is of no particular significance and cannot be interpreted as being due to the energy furnished by some decaying isotopes in the expanding shells of super-novae.
6. The best value for the total frequency of super-novae of all types in the brighter galaxies, for instance as listed in the Shapley-Ames Catalogue, is still that originally derived by Zwicky of one super-nova per galaxy per 350 years. The frequency of appearance of super-novae in the brighter galaxies of clusters ($m_{\max}$ to $m_{\max} + 3$) seems to be of the same order.
7. No cosmic rays and no radio waves have as yet been discovered from any super-nova in action.
8. Interesting work has been done by the radio astronomers at the California Institute of Technology on the radio spectra of 13 remnants of super-novae in our Galaxy. The measured spectral indices of these objects have a considerable spread, from $-0{\cdot}77$ to $+0{\cdot}56$. This spread is considerably larger than the spread of the spectral indices for extra-galactic sources. Also, correlations seem to exist between the spectral indices of super-nova remnants and their size and surface brightness.

Recommendations

a. In view of the increasing number of super-novae now being discovered it will be desirable to enlarge our committee and to include one or two spectroscopists who will specifically occupy themselves with observations of the spectra of super-novae and of their parent galaxies.

b. It is intended to publish a monograph in order to collect and review all of the data so far available.

c. A symposium on super-novae was originally planned for the summer of 1964. In view of the many symposia which have already been arranged for in conjunction with the IAU meeting at Hamburg it was decided to postpone the symposium until 1965.

As to desirable observations we recommend the following.

d. It is estimated that about twenty to thirty per cent of all super-novae in our fields have been missed because the central parts of many of the galaxies are being overexposed. This can be remedied through the use of shorter exposures or emulsions of the type of Royal Pan films.

e. More attention will be given to the optical properties of super-nova remnants in our Galaxy and attempts will be made to investigate super-nova remnants in external galaxies.

f. In agreement with suggestions made by Thackeray and Wild a systematic search for super-novae of the type V should be instituted. Since these objects often take many years to rise and decline (similar to η-Carinae) plate material over long periods of time should be investigated.

g. With photo-electric scanners becoming available, efforts will be made to obtain spectral data on super-novae over a large range, including the near infra-red.

h. The possibility should be looked into whether observations of super-novae from balloons and rockets are feasible and promising.

GENERAL STRUCTURE, COSMOLOGY

General physical properties, Dynamics, Evolution

J. Neyman and E. L. Scott have investigated the question as to whether the population of galaxies in the field has the same properties (luminosity functions of particular morphological types, relative abundances of morphological types, diameters) as the population found in clusters. The results obtained (**41**) indicate that the differences in magnitudes and in abundances of morphological types cannot be very striking. The difficulty of the problem is connected with the fact that the intensity of selection of objects to be included in a catalogue or in an observational programme depends upon the type of galaxies, on the interests of the investigators, etc., and also on whether an object is supposed to be a field galaxy or a number of a pair or of a larger system. Efforts are made to obtain substantial samples of single galaxies and of pairs under the same standard of selection. A catalogue now compiled by W. Zonn and Nancy Cook is expected to serve this purpose. Estimates of the dimensions of systems and the statistical relation to absolute magnitudes is under investigation (**42**). Estimates relating to selection factors of field galaxies have been discussed by A. H. Marcus (**43**).

The first volume of *Catalogue of Galaxies and of Clusters of Galaxies,* which was published in 1961 by F. Zwicky, E. Herzog and P. Wild (**44**), and the manuscript for the second volume are subjected to a series of statistical analyses. These analyses carried out so far have confirmed (*a*) the validity of a luminosity function for galaxies which rises monotonously with decreasing absolute luminosity, (*b*) the essentially uniform distribution of galaxies and of clusters of galaxies to distances which can be reached with the Palomar 48-inch Schmidt, (*c*) the existence of intergalactic obscuring matter, (*d*) the absence of clusters of clusters of galaxies. Zwicky claims a breakdown of Newton's inverse square law and of the general theory of relativity for distances surpassing ten million parsecs.

Up to the limit of the largest distances which can be reached with the 48-inch as well as with the 200-inch the structural and the physical nature of the various types of clusters of galaxies seems to be the same as that for the nearby clusters.

The Coma cluster and the cluster around NGC541 have been subjected to a very extended analysis. In the latter case for the brightest 100 members equipartition of kinetic energy is at least partly established in the sense that the fainter galaxies have a larger velocity dispersion than the brighter ones.

It was found that the richer a cluster the greater is the discrepancy between its mass, as derived from the luminosities of its member galaxies, and the mass inferred from the dispersion of their radial velocities. Zwicky proposes that the discrepancy is probably due to the presence of intergalactic stars and of loose groups of stars, although compact galaxies which are indistinguishable from stars and extended clouds of hydrogen molecules may be contributors also.

Compact galaxies have been discovered which are similar to the dense nuclei of large galaxies, containing millions of stars within surfaces of some tens of light years in diameter. Zwicky suggests that the compact radio galaxies 3C48, 147, 196, 273, 286 lie at the end of this sequence. Several thousand widely separated pairs of galaxies and multiple galaxies have been found with the 48-inch Schmidt telescope which are interconnected by various kinds of formations. These formations, by testimony of their spectra, contain generally both stars and gases (**45**).

G. and A. de Vaucouleurs (**46**) have studied the structure of the Virgo cluster and have published a review of recent studies of clusters and super-clusters (**47**).

H. M. Johnson (**48**) has studied details of the optical structure of the galaxies NGC5128 and M82 and its relation to the radio emission. In the latter case the origin of the A5 spectrum is discussed.

H. M. Johnson and J. M. MacLeod have discussed the spatial distribution of super-novae in galaxies (**49**).

G. O. Abell (**69**) investigates the luminosity function in rich clusters on the basis of photometry in two colours. The luminosity functions obtained so far are all similar to each other. A discontinuity in the slope of the integrated luminosity function is well defined and may be used as a criterion of relative distances of the clusters.

G. and A. de Vaucouleurs have published revised types of 1500 bright galaxies (**50**) in the system outlined in *Handbuch der Physik*, Vol. 53. A reference catalogue initiated in 1949 is essentially complete. Data on co-ordinates, morphological type, dimensions, magnitudes, colours, velocities and extensive notes are given for about 2500 galaxies (including the 1250 Shapley-Ames objects). Publication is expected in 1964.

T. Page has recalculated the average masses of galaxies in pairs from projected orbital motions, and the average ratio of mass to luminosity. Measures of dimensions, position angles and types of galaxies in over 100 pairs from Holmberg's catalogue have been studied to determine the distribution of angles between the axes of spirals in close physical pairs. The morphological types show strong preference for two galaxies of the same type in a physical pair. Relative sizes in pairs show that the linear diameters increase in the sequence E, Irr., Sa, Sb, Sc.

Mayall, P. O. Lindblad and Page have measured inclinations of lines in the spectra taken by Mayall and Humason. Taking into account estimated distances, P. O. Lindblad has discussed the angular velocity in relation to the diameter of the objects, the masses and mass-luminosity ratios. Page has discussed densities and angular momenta.

Zonn has made a revision of Holmberg's catalogue of double galaxies. Important information on double and multiple galaxies and on 'bridges' between neighbouring galaxies is yielded in the catalogues of Zwicky and Vorontsov-Velyaminov.

E. Holmberg has tried to apply to galaxies the results obtained by Salpeter and M. Schmidt on the evolution of the star population in the neighbourhood of the Sun. The relative state of evolution may be described by the intrinsic colour. The mass density (the total mass divided by the volume) is very well correlated with the colour. Galaxies with high mass density are red, while objects with low density are blue. The results appear to be of considerable importance in the discussion of cosmological models in their evolutionary aspects.

V. C. Reddish has continued investigations into the evolution of galaxies with particular reference to the change in the integrated properties of galaxies with time. The methods developed earlier have been applied to determining the ages of galaxies on the assumption that star formation follows a universal law (**51**). The consequences of the alternative assumption that all galaxies are of the same age, have been discussed.

M. S. Roberts (**52**) has made an extensive survey of the content of stars and gas in the galaxies, taking into account chemical composition, mass-luminosity ratios and colours. A study of the evolution process from gas to stars indicates that the stellar features of one morphological type does not change to another during a time of 10^{10} years.

Minkowski, Oort, Van Houten and M. Davis have completed an extensive study of the rotation and dynamics of the E7 - So nebula NGC3115. The rotation curve has a broad minimum between 35″ and 50″ distance from the centre (1000 to 1500 pc, if a distance of 6·2 Mpc is adopted). The measures extend to about 90″, or 2700 pc. At this point the rotational velocity is still increasing. For distances from the centre greater than about 35″, or 1000 pc, as measured in the equatorial plane, the mass-to-light ratio increases with distance, up to ratios of about 100. The mass-to light ratio for the nebula as a whole must be at least 50, and may well be as large as 100.

Theoretical works attempting to clarify various questions concerning the dynamics of galaxies are quite numerous. G. Contopoulos has, in addition to work on general stellar dynamics, together with G. Bozis investigated effects of perturbations in galaxies, especially those due to the approach of another galaxy (**53**). The escape of stars during the collision of

two galaxies has been studied. In the idealized case when one galaxy is considered as a point mass only 10% of the stars in the other galaxy escape.

I. King has investigated the structure of elliptical galaxies, comparing the observed luminosity profiles with theoretical ones from self-gravitating models based on a modified Gaussian velocity distribution and various mixtures of stellar types. If the velocity dispersion is known, the central value of mass/luminosity can be found from the central part of the luminosity profile. King has also published a review article on the dynamics of galaxies (**53a**).

T. Oki, M. Fujimoto and Z. Hitotuyanagi (**54**) considered a two-dimensional model of a galaxy which has both gravitational and magnetic fields. With the use of a perturbation method they found possibility to interpret the origins of a pair of spiral arms and the outflow and the drag motion of the gas. Fujimoto extended the computation to a galaxy with a more realistic gravitational field (**55**) and considered a model of galactic arms. He has proposed a dynamical explanation of the structure of barred spirals on the assumption that gas is ejected out of the central part of the system. The gas can follow the straight bar of large mass. Trailing arms emerge from the outer end of the bar made up of material given by successive destruction of the bar and outflowing gas.

P. Pişmiş (**56**) has developed a theory of the formation of spiral arms considering a gaseous component concentric with a wide compound of population II stars. A magnetic field in the gaseous part is approximated by a dipole with axis perpendicular to that of rotation. The spiral arms are formed by differential rotation of matter leaking out radially from the polar regions of the dipole.

J. Tassoul (**57**) has developed a general magneto-hydrodynamics theory of mass motions in gaseous systems.

A general review of magnetic fields and spiral structure has been given by D. G. Wentzel (**57a**).

In the model of spiral structure developed in numerical computations by P. O. Lindblad (**58**) it is shown how a system of annular formations small deviations of a bisymmetrical nature can cause a development of typical spiral structure including barred types. Starting from this model B. Lindblad (**59**) has shown that a trailing spiral arm has a powerful capacity of attracting and assimilating surrounding matter. On this basis a circulation model of spiral structure of a quasi-steady type has been developed as an alternative to the possibility of a quasi-periodic development of spiral structure indicated by P. O. Lindblad.

S. van den Bergh (**60**) has investigated statistically the stability of clusters of galaxies. He finds that 76 per cent of all elliptical galaxies are at present members of clusters, which implies that most clusters containing a strong population of elliptical galaxies must be stable over periods comparable to their ages. An investigation of the morphology of galaxies suggests that the evolutionary history of galaxies is affected both by gradual evolution and by explosive events. In particular it is suggested that the class of Sa galaxies with small nuclei have been derived from normal Sc galaxies from which part of the interstellar gas has been removed by a violent explosion. It is also suggested that the So galaxies in clusters owe their present appearance to internal explosive events rather than to mutual collisions which, with the currently accepted distance scale, must be quite rate.

D. Sciama (**61**) has shown that cosmic rays and radio astronomical data are consistent with an open model of the galactic magnetic field, in which the lines of force run into intergalactic space and close around the local cluster of galaxies. The field is associated with an ionized gas of density 10^{-27} g cm^{-3}. The halo of the Galaxy may be regarded as that part of the intergalactic gas which is under the gravitational control of the Galaxy. In this model the cosmic rays and the relativistic electrons spend most of their time in intergalactic space. A magnetic field in

spiral arms, disk, halo and intergalactic space of about 5×10^{-6}, 2×10^{-6}, 5×10^{-7} gauss is suggested.

S. Hayakawa and Y. Yamamoto (**62**) have computed the intensity and the energy spectrum of high energy γ-rays arising from the collisions of cosmic ray protons and thermal photons in the intergalactic space.

K. Ishida (**63**) finds negative correlation between H I gas and young stellar objects in the Magellanic clouds. Together with S. Aoki (**64**) he has studied collisions and relaxation time for gas clouds in galaxies as basis for a study of two evolutionary sequences, spherical and flat.

J. L. Sérsic (**65**) has discussed the time scale of the Universe, starting by defining the extragalactic scale of distances in terms of the absolute magnitude of the RR Lyrae stars and the corresponding time scale is compared with the nuclear scale given by the theory of stellar evolution according to computations by Hoyle. If the Hubble constant is $H = 116$ km sec^{-1} Mpc^{-1} and the absolute magnitude of the RR Lyrae stars is $M_B = 0{\cdot}00$, it is concluded that the initial abundance of hydrogen should be smaller than 0·66 in the Old Population I. A detailed study of H II regions (**66**) gives a theoretical interpretation of the correlation between diameters of the largest H II regions and the morphological type of the galaxy. He concludes that the age of the galaxies is approximately the same but that their evolutionary rates depend on the morphological type. J. L. Sérsic and R. Sisteró are investigating the pulsational stability of a plasma in an external axisymmetrical magnetic field under the action of a concentric gravitational field arising from another mass distribution. This may have application to matter in elliptical galaxies.

According to S. van den Bergh (**67**) studies of the metal abundances of stars in the Galaxy lead to the following conclusions. (*a*) The heavy element enrichment of the interstellar medium was well advanced at the termination of the halo phase of stellar evolution. (*b*) The rate of heavy element formation in the Galaxy has declined more rapidly than the rate of star formation. (*c*) The enrichment of the interstellar medium in heavy elements has been negligible during the last $4{\cdot}5 \cdot 10^9$ years.

A. G. Wilson and D. Edelen have conducted work at the Rand Corporation on relativistic discretization of diameters in clusters (Preliminary results were reported at the meeting of the American Astronomical Society in July 1963). Edelen has shown that the Einstein theory of general relativity, when used in conjunction with the epistological equivalents of certain well known properties of galaxies, predicts a relation between the galaxian semi-major axis r and the eccentricity ϵ (or ellipticity) of the form $r(n, m, \epsilon) = \text{const.}$, where n is a positive integer and $0 \leq m < n$. In the particular case $\epsilon = 0$, the relation between r and n takes the form,

$$r^2\xi = n(n + 1)$$

independent of m, where ξ is a physical parameter corresponding to the jump in the total energy density across the surface of the world tube representing the galaxy, as seen by an observer moving along an intrinsic time line of the surface. If ξ is constant, or of limited variation, it follows that the diameters of Eo galaxies should exhibit discretization of size.

The earlier data of Wilson (**68**) which first suggested discretization among globular galaxies have been re-assessed and combined with new measures. The present observational confirmation rests on (1) Wilson's angular diameters of Eo galaxies in six clusters re-measured on 200-inch plates. (2) The diameters of all Eo galaxies in the new Reference Catalogue of de Vaucouleurs, (3) the fine structure in Abell's (**69**) luminosity function of the Coma cluster. The diameter redshift relation for cluster galaxies confirms the Hubble law and reveals the hitherto unsuspected relation that the redshifts of all clusters so far published obey the empirical relationship $\mu\, n(n + 1) = K_\sigma$, where $\mu = \frac{1+z}{z}$, n is a positive integer, and K_σ is a limited set of discrete constants related to the parameter ξ of Edelen's discretization function.

Cosmology

In conclusion, some investigations in which cosmological theory has been applied to observational problems may be briefly mentioned. Sandage (**70**) has examined the possibility of using observations made with the 200-inch Hale telescope to distinguish among the members of the sub-group of general relativity models of the universe characterized by a zero cosmical constant and also to contrast these models with the steady-state model. He points out that the observations of redshift versus apparent magnitude are the most promising for the purpose. The theoretical formulae for some observable quantities in certain world models have been redeveloped by van Albada (**120**). Sandage (**71**) has also investigated the effect on the redshift versus apparent magnitude relation of a postulated evolutionary change in the absolute magnitudes of the brightest members of clusters of galaxies. Significant changes in the value of the acceleration factor are obtained if the evolutionary change of absolute luminosity amounts to $0^m{\cdot}4$ or $0^m{\cdot}3$ per billion years. Observational evidence for such changes is difficult to find though estimates of colour variations due to evolution have been said to amount to $0^m{\cdot}03$ per billion years and there are indications that a residual Stebbins-Whitford effect may be present in the spectra of galaxies (**72**). Sandage (**73**) and McVittie (**74**) have also examined the possibility of detecting changes in the redshift, the bolometric apparent magnitude and the flux-density of a given source of radiation observed by a given observer over great lengths of time. There seems to be little hope of detecting such changes observationally because of their very small magnitudes.

A problem that has been much discussed is that of the distribution in depth of extra-galactic radio sources (**75**). The number, N, of such sources which have flux-densities not less than S appears to follow the law that N is proportional to $S^{-(3+\mu)/2}$, where μ is variously estimated by the observers as lying between 0 and 1. It can be proved (**76**) that such a relationship cannot exist in an expanding universe unless it is assumed that there were intrinsically more radio sources in the past than there are now or that they were intrinsically more powerful radiators This result also assumes that there is instantaneous uniformity of number-density of sources and of their intrinsic power output. Specific examples have been given by Oort (**77**) and by Davidson (**78**) and the effect of the introduction of a luminosity function has also been examined. McVittie and Roeder (**79**), following up the pioneer work of B. Y. Mills and of R. Minkowski, have worked out the theory of the luminosity function for radio sources all of which share in the expansion of the universe. They show that a luminosity function is unable to reconcile theory and observation and that secular variations in number-density and power output must presumably again be introduced. A theory of a different kind is due to Hoyle and Narlikar (**80**) who suggest that it is possible to combine the steady-state theory, which assumes a strict uniformity in the spatial distribution of all galaxies, with large-scale statistical irregularities in the distribution of those galaxies which are radio sources. If these ideas are accepted, it can be shown that the observed relation between N and S can be recovered. Still another theory is due to Sciama (**81**) who postulates that half of the sources usually labelled extra-galactic are in fact weak sources in our Galaxy. The observed relation is again recovered; it is not however explained what the postulated galactic sources may be.

The total background radiation that would be received by an observer at a fixed location in an expanding universe has been evaluated in detail both at optical wave-lengths and for the gamma-ray flux (**82**).

G. S. Hawkins (**119**) has attempted to interpret the data on redshifts in terms of a theory in which the redshift varies as the square of the distance.

As appendices to this report, are printed hereafter a report on researches on galaxies made in U.S.S.R. (appendix 1, to which references are included in the general bibliography) and three rather distinct reports (appendices 2, 3 and 4) following the general bibliography, and accom-

panied by specific list of references, on Magellanic Clouds, on extra-galactic and galactic radio sources, and on cosmological researches made in U.S.S.R.

BERTIL LINDBLAD
President of the Commission

G. C. MCVITTIE
Secretary

Note ajoutée à la correction des épreuves par le Secrétaire Général

Il peut être utile aux membres de la Commission d'apprendre la parution récente de l'ouvrage: *Catalogue of Galaxies and of Clusters of Galaxies*, Vol. II, F. Zwicky et E. Herzog, Editeurs (California Institute of Technology, Pasadena).

APPENDIX I. RESEARCHES ON GALAXIES MADE IN THE U.S.S.R. DURING 1961–1963

(prepared by B. A. Vorontsov-Velyaminov)

Optical Region

Markarian, Hovhannisian and Arakelian (**83**) made the detailed colorimetry of galaxies NGC2976, 3031, 3034 and 3077. Conclusions upon the distribution of stars of different colour were drawn. Kalloglian (**84**) made two-colour photometry of NGC7331 with a conclusion that its arms are trailing. Markarian (**85**) observed Hα in emission in M82. He rejects the presence of absorbing matter as the reason for the contradiction between its colour and spectrum. Instead he believes that there is a rapid formation of the young stars of population I. Moroz (**86**) measured the stellar magnitude of the jet in NGC4486. Vorontsov-Velyaminov (**87**) investigated the distribution of dust in galaxies of different types. The thickness of its layer varies from 60 to over 1000 parsecs. In the elliptical galaxies the distribution of dust is quite different from that of the stars. Pskovsky (**88**) studied the distance moduli of the nearest galaxies according to the cepheids. Difference of the relation period-amplitude for the cepheids of types A,B,C according to Eggen must be considered. Then the distance from the cepheids is in agreement with that derived from novae, if the absorption inside M31 is taken into account.

Genkin (**89**) made a broader revision of the criteria for the distance scale studying mainly the Magellanic Clouds. For the Hubble constant he obtained 120 km sec^{-1}. He finds also (**90**) that in M31 the negative K-effect is present.

Pskovsky (**91**) calibrated the luminosities of galaxies of different sub-types starting from the study of the Virgo cluster. The ratio of ellipticals to the spirals in the general field and in the clusters of Virgo and Hercules is the same. Determination of luminosities for different sub-types according to the recent classifications were made by him (**92**) without using their red-shifts. Pskovsky (**93**) investigated also the luminosities of radio galaxies. The spectral indices and the monochromatic absolute radio-magnitudes are strongly correlated. This enables the determination of distances to radio galaxies not identified optically. Kalloglian and Tovmassyan (**94**) received a correlation between the mutual distance of double radio-galaxies and their power of emission. On the average their absolute magnitude is 26·1, while for the single radio galaxies it is $-25{\cdot}2$.

Pskovsky (**95**) studied the distances, motions and distribution of galaxies nearer than 15 Mpc. He finds that the Fornax cluster is not a hypergalaxy, but an arm of our Virgo hypergalaxy. Galaxies there do not revolve about an axis of the system, as suggested by Vaucouleurs, but rather form a swarm with random motions around the central condensation.

The following super-novae were found at the Sternberg Institute in Moscow:

Galaxy	1950 α	δ	First obs.	M_{ph}	
IC3112	$12^h\ 15^m\ 18^s$	26° 18·6	1963 Feb. 19	15·8	21″SE(Kuročkin) (**96**)
NGC4178	12 10 13	11 08·2	1963 May 14	14·5	36″SW(Zaitseva) (**97**)

Pskovsky (**98**) studied the frequency of super-novae.

Super-novae of type II appear some 17 times less frequently in galaxies of moderate luminosity than in the giant galaxies.

Crimean astronomers (**99, 100**) on the 2·6 m telescope obtained photographs of 58 galaxies through various filters using the image converter. The photographs made in the light of Hα show numerous H II regions. Some of them obviously are not related to the condensations of stars. Some galaxies show complex structure of the nucleus in Hα-light and some jets are visible only in Hα. On the 50-inch telescope astronomers from Moscow (**101**) succeeded in obtaining the photographs of many galaxies with the image converter. The exposures in the integrated light were only 20 seconds. Some peculiar galaxies were studied photometrically.

Vorontsov-Velyaminov and Krasnogorskaja (**102**) issued Part I of the *Morphological Catalogue of Galaxies*. It contains 7200 galaxies brighter than 15^m from +90° to +45° in declination. Estimates of the surface brightness, of dimensions of the inner and of the outer portion and of inclination are given as well as description of the appearance by means of appropriate symbols. The third part of the same catalogue from +15° to −9° in declination was issued by Vorontsov-Velyaminov and Arhipova (**103**). The second part compiled by them from +45° to +15° is in press (**104**).

Ambartsumian (**105**) studied the *c* instability phenomena in systems of galaxies. He gave many new arguments in the favour of the idea that many systems are disrupting and that the spiral pattern, the globular clusters and the dwarf companions are formed by means of ejection from the nuclei of massive galaxies. In this connection may be quoted a number of other papers: 'Problems of extra-galactic researches' by Ambartsumian (**106, 107**), 'On some aspects of Ambartsumian's hypothesis upon the origin of galaxies' (**108**) by Vorontsov-Velyaminov, where he finds that some facts support the hypothesis while some others do not. The same author (**109**) considered the possibility of explosive formation of galaxy patterns. Kallogian (**110**) and Markarian (**111**) contributed to Ambartsumian's research the papers 'On the dynamical instability of several groups of galaxies' and 'A physical chain of galaxies in the Virgo cluster'.

In connection with Ambartsumian's statement upon the efficiency and activity of cosmogonic importance of galactic nuclei, the 'stellar' nuclei of some 40 galaxies were measured by Gorbatschev and Vorontsov-Velyaminov (**112**). Gratchev (**113**) measured the parameters of the spiral arms in a number of galaxies not investigated formerly by Danver.

Eigenson (**114**) issued an extensive monograph on extra-galactic astronomy.

Radio Region

Shklovsky (**115**) exposed his new ideas upon the nature of radio galaxies. He constructed a diagram 'absolute radio magnitude-linear dimensions', which shows two sequences. The main one is characterized by an increase in luminosity with increasing dimensions and the giant branch by a rapid decrease of luminosity with increasing dimensions. He believes that during the inflow of intergalactic gas to the nucleus the acceleration of charged particles takes place.

Kardashev, Kuzmin and Syrovatsky (**116**) discussed the nature of radio emission of Cygnus A. The energy spectrum of injected electrons varies with time due to the losses by emission.

The variation depends on energy interval. Thus the age of CYG A is $5 \cdot 10^5$ years, density 10^{-29} g cm^{-1} and velocity of expansion 10^5 km sec^{-1}.

Tovmassian (**117**) discussed 34 possible identifications of radio sources with galaxies in clusters which in most cases were found by him to be doubles. Their number does not depend on the richness of the clusters. The same author and Kalloglian (**118**) made still further identifications of radio sources, 22 in number. 16 of the galaxies suspected are double. The latter could not be formed by collision.

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