

28. COMMISSION DES NEBULEUSES EXTRAGALACTIQUES

Report of Meetings

PRESIDENT: N. U. Mayall.

SECRETARY: G. C. McVittie.

Meetings were held on 16 August, 11^h – 12^h, 19 August, 10^h – 12^h, 21 August, 9^h – 11^h, and 22 August, 15^h – 17^h. A joint discussion with Commission 40 was held on 21 August, 14^h – 17^h.

Business meetings

At the business sessions, the following matters were dealt with:

(a) The *Draft Report* was approved subject to typographical corrections.

(b) It was announced that J. B. Sykes had prepared an English translation of G. Ogorodnikoff's 'Dynamics of Stellar Systems', which was being published by the Pergamon Press.

(c) The group of astronomers carrying out the International Super-nova Search should become a Committee of the Commission, with the following membership: C. B. Bertaud, E. F. Carpenter, G. Haro, B. V. Kukarkin, G. Mulders, L. Rosino, J. L. Sérsic, P. Wild, with F. Zwicky as Chairman.

(d) A list of eight names was drawn up by the Commission of persons who might be members of the Organizing Committee. The President was asked to decide on four persons from this list who would form the Organizing Committee. He selected the following: E. Margaret Burbidge, B. Y. Mills, A. R. Sandage and A. D. Thackeray. As proposed by the Executive Committee, the new President would be B. Lindblad, and the Vice-President, R. L. Minkowski.

(e) The Commission sent forward to the Executive Committee of the Union a resolution that the name of the Commission be changed to 'Commission on Galaxies' (Commission des Galaxies). [This was approved by the Executive Committee and the General Assembly.]

(f) Oort proposed that the word 'inclination' in extra-galactic research should be used only for the angle between the equatorial plane of a galaxy and the plane of the sky, at the position of the galaxy. The Commission endorsed the proposal and recommended it to all astronomers working on galaxies.

(g) The President proposed, and the Commission approved, that G. C. McVittie should continue as Secretary of the Commission for the next General Assembly.

(h) Sub-Commission 28a on the Magellanic Clouds was reconstituted as a Committee of the Commission, with the following membership: S. C. B. Gascoigne (Chairman), F. J. Kerr, J. L. Dessy, E. M. Lindsay, A. D. Thackeray, W. G. Tift and T. Walraven. The Committee held a special meeting and agreed to the following recommendation regarding co-ordinate systems in the Magellanic Clouds: where the use of a rectangular co-ordinate system is desirable, the Committee recommends that the (ξ , η) system of Wesselink be preferred to the Harvard (X , Y) system.

(i) An *ad hoc* group on Galaxy Photometry met under the chairmanship of G. de Vaucouleurs. It was agreed that an informal liaison group should be established: G. de Vaucouleurs (Dept. of Astronomy, Univ. of Texas, Austin 12, Texas) will centralize informa-

tion on programs, equipment, etc., and circularize interested astronomers. A list of a dozen or less 'Reference Objects' in the equatorial belt of the sky will be set up. A preliminary list includes NGC 3379, 4486, 3115, 4111, 4594, with others to be selected after further exchange of views. Observers undertaking extensive programs of surface photometry (iso-photometry) will be encouraged to observe these objects in order to check techniques and to provide theorists with the best possible data on some typical systems. Recent and current observing programs were reviewed: a detailed tabulation will be circularized later after observers have communicated more detailed information. This will include both detailed surface photometry and integrated magnitudes and colors. The new iso-photometer of the University of Texas was described and tracings shown: this instrument will be commercially available in 1962. Koelbloed indicated that an iso-photometer will be tested shortly at the Sterrekundig Instituut in Amsterdam.

(j) Considerable attention was devoted to the question of the contamination of space in the neighbourhood of the Earth and, in particular, to Project West Ford. This was described by Liller on the general lines of his article in *A. J.*, **66**, 105, 1961. At the last session of the Commission, Oosterhoff described the two resolutions on space contamination that were to be presented to the General Assembly by the Executive Committee of the Union. The Commission passed a resolution supporting the action of the Executive Committee.

(k) The President asked Holmberg to report on the work of the *ad hoc* Committee on catalogues of galaxies of which he was Chairman. Holmberg stated that his Committee would prefer to leave the question open until the 1964 General Assembly. Zwicky, Vorontsov-Velyaminov and de Vaucouleurs had issued, or were issuing, their own catalogues outside the purview of the committee. By 1964, these catalogues would be available and, at that time, it would be easier to decide whether any further catalogues of galaxies would be needed and, if so, what their form should be.

The President asked Zwicky, de Vaucouleurs and Vorontsov-Velyaminov to describe their catalogues briefly.

Scientific meetings

At the sessions devoted to reports of scientific work, the first speaker was *J. L. Sérsic* who described the work at Córdoba on the Shapley-Ames galaxies brighter than the eleventh magnitude and lying south of -25° . Photographic isophotes have been traced and a set of maps will be ready by the end of 1961. A search for variable stars in NGC 55 and 300 is being conducted. Standardized plates for photometric purposes for the NGC 1566 group have been obtained. Peculiar objects such as NGC 1487 and 3256 have been studied photometrically and particular attention is being devoted to NGC 6438. The total photographic magnitude of NGC 5128 has been determined to be 8.0 and the distance of the galaxy has been found to be 4 Mpc.

The next speaker was *W. A. Baum*, who gave the following report on his work:

"The most powerful test of world models is the relationship between the redshifts and the bolometric magnitudes of galaxies belonging to clusters, but redshifts well beyond the usual spectrographic limit at $z \sim 0.2$ are needed to make this test decisive. In the present program, the redshifts of three clusters beyond $z \sim 0.2$, as well as those of five nearer clusters, have been observed by a completely photo-electric method undertaken in 1955. These redshifts are obtained by measuring each galaxy photo-electrically in six or eight colors ranging from ultra-violet to infra-red. The observations are translated into a spectral-energy distribution-curve in terms of energy per unit wave-length as a function of wave-length. When plotted on log-log scales, the $E(\lambda)$ curve for a distant, redshifted galaxy is similar in shape to

the $E(\lambda)$ curve for a nearby galaxy having no appreciable redshift, but the two curves are displaced from one another. The horizontal ($\log \lambda$) displacement yields the redshift, while the vertical displacement yields the difference in bolometric magnitude. There are no K-corrections except for a geometric one due to the logarithmic abscissa.

“The uncertainties in the magnitudes are greater than those in the redshifts but are not believed to be serious enough to upset the general nature of the results. The magnitudes require normalization to a standard intrinsic diameter, they require the relating of the luminosity functions of the various clusters to one another, and they are more vulnerable than the redshift to any evolutionary effect. For the normalization of magnitudes to a standard diameter, the intensity profiles of some representative galaxies have been measured photo-electrically. The relating of luminosity functions can be improved by further photometry. The dependence on evolution can be estimated from a population model for elliptical galaxies that has been derived in connection with the present program.

“The largest redshift thus observed is $z = 0.44 \pm 0.03$ for the cluster found by Minkowski in the position of Cambridge Radio Source 3C 295. On the assumption that the emission line found by Minkowski at 5448 \AA is [O II] 3727, the validity of the photo-electric method is well confirmed out to the distance of that cluster. The two main observational problems ahead are to find more clusters in this range or beyond, and to construct a multi-channel instrument for accelerating the observations.

“It is difficult to judge the probability of finding additional clusters through the identification of radio sources, but it would be over-optimistic to hope for an adequate sample from that method alone. We shall probably have to depend mainly upon optical discovery. Photographic searching with the 48-inch Schmidt telescope has already been explored with the help of techniques for slightly extending its threshold beyond the limit of the Sky Survey plates, and some further work of that kind will probably be worth pursuing. Searching with the 200-inch telescope may also be practicable when large-field image converters become available.

“The photo-electric redshift-magnitude observations themselves should be greatly accelerated by measuring all colors at once instead of one color at a time. A multi-channel photometer is now being prepared for permanent installation in the east side-arm of the 200-inch telescope. In its initial design the instrument consists of an $F/16$ zero-deviation liquid-prism spectrograph and eight pulse-counting channels. It is a rotatable structure about 6 meters long with provision for co-ordinate offsets, for guiding, and for automatic commutation between object and sky. We contemplate the eventual addition of channels for simultaneous observation of object and sky.”

de Vaucouleurs described the work that is being done on the photographic photometry of bright galaxies at a number of observatories. He mentioned the Harvard College Observatory–University of Texas project in some detail, describing the iso-photometer he was using and the isophotes of galaxies that had been obtained. He then proceeded to review the work on photo-electric photometry being carried out by a number of workers. *de Vaucouleurs* emphasized the need for co-ordination and co-operation in studies of this kind, in order to prevent duplication of effort and also to secure an agreed method of presenting the results. He thought that standard objects should be selected, such as NGC 4486, 3115, 4595, etc., to serve the same purpose as the standard reference stars in stellar photometry. It was agreed that a group of interested astronomers should meet on August 23 to discuss these problems of co-operation in the work on the photometry of galaxies.

Contopoulos described theoretical work being carried out at Thessaloniki. It concerns the events that occur during a collision between two galaxies. The perturbations produced in

stellar orbits during the collision, and which arise from the ellipticity of the galaxies, are insignificant if the orbits lie close to the planes of symmetry. It is, however, possible that, under certain conditions, ejection of stars from the galaxies can take place. Further work is planned on this aspect of the problem in order to find the order of magnitude of the ejected mass, the relationship to the observed tails of galaxies, etc.

Hoffmeister spoke of the observations he had made at the Boyden Observatory in 1959. He had taken plates with the 250 mm Metcalf camera in order to investigate in 13 fields the RR Lyrae stars of the galactic halo. The plates were checked for transparency of the areas by marking and counting extra-galactic objects. About 2 to 3 degrees north of ι Mic a region of 15 to 20 square degrees was found to be practically free of extra-galactic objects. Only 5 faint and small objects were found, where statistically 20 to 30 from 12^m to 16^m might have been expected. This region shows a rather sharp limit. The surprising fact is that both normal galactic stars and RR Lyrae variables of the galactic halo are present in the expected number. Thus, if there is an absorption effect, the absorbing cloud must lie beyond the galactic halo. For several reasons such a cloud is expected to merge gradually into the unobscured surroundings. So there must be an increase of mean brightness of the galaxies and an increased number of elongated forms, when one proceeds from the centre of the obscured region to the undisturbed area, the latter effect being caused by the fact that any absorption depresses first the fainter outer parts of a galaxy, independent of its distance. Thus five different areas were investigated: 1, the region of strongest obscuration; 2, 3, and 4, three concentric zones surrounding this region, of 30' breadth each; 5, the undisturbed area outside the 4th zone. Here are the results:

	Mean Magnitude \bar{m}	Number n	Number n	Percentage of elongated forms
Area 1	15.75	5	5	0.0
„ 2	14.97	36	25	24.0
„ 3	14.85	36	19	31.6
„ 4	14.69	34	22	36.4
„ 5	14.58	106	46	47.8

The effect on the left side might eventually be due to the tendency toward grouping. On the right side, to avoid the grouping effect, only the galaxies of 15^m and fainter have been included. Thus strong evidence is given that there really exists a distant absorbing cloud in this region of the sky. The absorption might be estimated to be at least 2 or 3 magnitudes, probably more. As to the size and shape of the cloud, the most probable hypothesis might be that it is of similar size to the Magellanic Clouds, and that it is a member of the Local Group.

E. Margaret Burbidge then gave an account of the work done at Yerkes and McDonald Observatories on the measurement of rotation curves of spiral and irregular galaxies, and of the determination of mass distributions and total masses from these measurements. The Table contains the presently available masses and mass-to-light ratios for spiral and irregular galaxies, not only from work by Prendergast and the Burbidges at Yerkes, but also from work by Mayall, de Vaucouleurs, Volders, Münch, and Raimond *et al.* In the Yerkes work, a long slit (5') was used so that one or two spectra usually covered most of the major axes of suitably oriented galaxies. The H α and [N II] emission lines were then measured at points along the length of the slit, and absorption lines were measured in the central regions. The night-sky lines of [O I] and the Ca II absorption lines H and K on twilight or moonlight spectra, all extending the full 5', provided a check on the accuracy of the spectrographic curvature correction and on systematic errors in the measurement of both emission and absorption lines.

The table shows a general increase in \mathcal{M}/L in the progression of types Irr-Sc-Sb-Sa, but the correlation is only loose, partly because of the effect of internal absorption within the galaxies (e.g. M 82, in which L was not corrected for the undoubtedly large internal absorption).

Galaxy	Type	$\mathcal{M}/\mathcal{M}_{\odot} \times 10^{-10}$	\mathcal{M}/L_{pg} (solar units)
M 82	Irr.	1.5	7.4
NGC 55	Irr.	~4	~6
NGC 3556	Irr.-Sc	1.4	1.4
LMC	Irr.-Sm	1.3	4
NGC 3646	Sb-Sc(p)	> 20-30	> 2.5-4
NGC 2146	Scp	1.8	3
M 33	Sc	1.8	11
NGC 157	Sc	6.0	1.9
NGC 3504	SBb	0.3-0.9	< 1
NGC 5055	Sb-Sc	5.5	~2.8
NGC 2903	Sb	4.9	> 4.2
M 101	Sc	1.4	13
NGC 5005	Sb	9	6
M 81	Sb	15	20
M 31	Sb	34	23-10
NGC 3623	Sa-Sb	20-30	10-20

Problems arising in the Yerkes-McDonald work were mentioned, such as: (a) whether non-circular motions might occur in some cases; (b) whether a galaxy might have more than one system with non-coplanar principal planes; (c) the difficulty, related to (a) and (b), arising in some cases, of determining the equatorial plane. NGC 3646, a very large Sbc galaxy with an outer structure apparently not in dynamical equilibrium, was cited as an example of (a). NGC 4736 was cited as an example of (c). A mass for the latter galaxy is not yet available.

Richard Miller followed with a report on the detailed photometric study of the EO galaxy NGC 3379. A point-by-point scan with a photo-electric photometer has been carried out. About 400 points were measured, distributed over the galaxy image, to determine the position dependence and to check the symmetry. The colour is nearly constant but becomes slightly redder within half a minute of arc from the centre. A preliminary account of the reductions was given.

In the discussion following the papers by Dr Burbidge and by Miller, the President was urged to publish his results on the rotations of some 80 galaxies that he has observed.

Zwicky spoke on the International Super-nova Search. He pointed out that the division of super-novae into two classes only, Type I and Type II, is likely to be inadequate. He thinks that there is already an indication that five types may be needed. He cited the super-nova in NGC 4303, whose light-curve fluctuated about the maximum for 60 days, and whose spectrum looked somewhat like that of an O-type star. He also referred to the super-nova in NGC 3003, whose spectrum was very difficult to understand. Since the year 1885, 100 super-novae have been found. It was to be expected that the Super-nova Search should produce about 40 super-novae per year from now onwards. Zwicky thanked the National Science Foundation of the United States, and the governments of all the countries in which the observatories taking part in the Search lay, for their financial support of the program.

Vandekerhove described his ideas on the spectro-photometric gradients of galaxies and *Oosterhoff* drew the attention of the Commission to the work, which was proceeding under

his direction, on the Sculptor dwarf system in Ursa Minor. A complete analysis of Baade's 200-inch plates of this object was in progress. Over ninety variables had been found and these were probably all that existed.

The work done at the Burakan Observatory, since 1958, on the colorimetry of galaxies was discussed by *Markarian*. A photographic image of a galaxy, made with a Schmidt telescope, is measured by a fast-acting microphotometer that has a square diaphragm. Each square section of the galaxy image is measured and there is no overlap of squares. A map of the distribution of brightness and colour over the galaxy image is thus produced.

These maps can be used to find the integrated brightness and colour of the galaxy as a whole, and also of its various regions. The change of brightness and colour between centre and outer parts was thus determined, as were these quantities for the disk alone, for the spiral arms, for the bar of barred spirals and for stellar associations. The relative blueness of the outer parts of spirals was noted, in agreement with de Vaucouleurs' results. The effect is due to the change in composition of the disk population and only partially to the increasing amount of radiation from the spiral arms as the outer parts of the spiral are attained. Asymmetry in the distribution of brightness and colour was observed in many galaxies. In the case of M 51 the asymmetry is explained by the assumption that there is a large quantity of dark matter in the region between the two components of the galaxy.

28 a. SOUS-COMMISSION DES NUAGES DE MAGELLAN

Report of Meeting, 23 August 1961

PRESIDENT: S. C. B. Gascoigne.

SECRETARY: M. W. Feast.

The *Draft Report* was approved without a discussion. The President drew attention to the fact that there had been a meeting of the Sub-Commission in Cordoba in December, 1960.

The President initiated a discussion on nomenclature for variable stars in the Magellanic Clouds. At present the majority of variables in the Clouds were discovered at Harvard and have HV numbers. However, there are considerable doubts as to whether many of the variable stars can now be recovered as the positions are not generally very accurate and no maps are available for many. Furthermore, extensive work is already in progress which will produce many more variables (*e.g.* the work of the Greenwich astronomers, Dessy, etc.). Dr Eggen stated that all Greenwich variables would be given a Greenwich number irrespective of whether or not they had already an HV designation. This was necessary since it was difficult to be certain in many cases of the identification with an HV star. Dr Gascoigne spoke of the help he had received from Dr Shapley and the Harvard Observatory in finding HV stars. Much of the unpublished Harvard material is now in Dr Gascoigne's keeping at Mount Stromlo in card-catalogue form. The best way to make use of this material was discussed, but no final decision was reached. An attempt to map all the variables had been begun at Mount Stromlo, but not completed. Dr Tiffitt offered help in the construction of charts of Harvard variables. Dr Thackeray proposed a motion that all observers be strongly urged to publish finding charts for all new variables. This motion was passed unanimously. It was also agreed that observers should be urged to print both the scale and orientation on each map. The normal practice (North at top, West to the right) should be followed, and Dr Bok suggested