28. COMMISSION DES NÉBULEUSES ET DES AMAS STELLAIRES

PRÉSIDENT: M. E. P. HUBBLE, *Mount Wilson Observatory, Pasadena, Cal., U.S.A.*

MEMBRES: MM. Bowen, Jeans, Knox-Shaw, Lampland, Lundmark, Madwar, Parvulesco, Mme Roberts, MM. Reynolds, Shapley, V. M. Slipher, Trumpler, Vanderlinden, Van Maanen, Von Zeipel, W. H. Wright, Zanstra.

During the time elapsed since the last general assembly of the I.A.U., many activities have been pursued by the astronomers engaged in research work in the wide fields of problems concerning nebulae and clusters. In fact a number of important discoveries have been made and earlier work has been extended in a way to consolidate earlier views or revise them. The *embarras de richesse* in this field and the extremely short time available for the compilation of a report make it impossible to present anything else than a few short notes partly written by heart and only intended to express personal views on the question of how the research work on nebulae and clusters might be carried on.

The following report is mainly restricted to work done since the last meeting of the I.A.U., but in a few cases it has been necessary to mention earlier results.

A. ANAGALACTIC OBJECTS

(*a*) *Dimensions and spatial distribution.* The publication in 1929 (*Ap. J.* **69**, 103—*Mt Wilson Contr.* 376) of Hubble's extensive researches concerning the Andromeda nebula as a stellar system is an outstanding feature of the work within the field covered by this report. Altogether 350 photographs taken with the 60- and 100-inch reflectors at Mount Wilson were scrutinized and fifty variables and sixty-five novae were found by Hubble in the Andromeda nebula. The paper contains a careful study of the light curves of forty-six cepheids and a few other variable stars and sixty-three novae. Data for altogether eighty-five novae were given. Inasmuch as many of the novae are very incompletely observed it is necessary to complete the curves by adding a correction to the observed maximum. In order to derive the most probable value for the maximum light, the following small table might illustrate the accuracy with which this correction can be computed.

Mean apparent magnitude at maximum				
Observed	Correction	Computed	Number of objects	Authority
$17^m{\cdot}03$	$-0^m{\cdot}69$	$16^m{\cdot}34$	20	Lundmark 1925
$17^m{\cdot}20$	$-0^m{\cdot}76$	$16^m{\cdot}44$	85	Hubble 1929
$17^m{\cdot}21$	$-0^m{\cdot}78$	$16^m{\cdot}43$	97	Lundmark 1932

The very small dispersion around the mean is illustrated from the following table.

Dispersion or "mean error" observed	No. of objects	Computed	No. of objects	Epoch
$\pm 0^m{\cdot}576$	20	$\pm 0^m{\cdot}611$	20	1923
$\pm 0^m{\cdot}603$	85	$\pm 0^m{\cdot}576$	71	1929
$\pm 0^m{\cdot}600$	97	$\pm 0^m{\cdot}571$	79	1932

The real dispersion in the absolute magnitude of the Andromeda novae is considerably smaller. Unpublished work by Lundmark suggests that its value cannot surpass $\pm 0^m{\cdot}48$. Except the cluster type variables which have a dispersion around their mean of $\pm 0^m{\cdot}75$ or even smaller, the novae seem to be the group of stars which displays the most "constant" light* statistically speaking.

* This applies to their light at maximum.

https://doi.org/10.1017/S0251107X00016540 Published online by Cambridge University Press

In parallel with these investigations a considerable work has been performed by H. Shapley and his co-workers as to the two Magellanic Clouds which we now know are the nearest of all anagalactic objects.

In 1924 H. Shapley derived the value: 101,800 light-years for the distance of the Small Cloud, based upon periods and light-curves for 65 cepheids (*H.C.* 255) and the improved galactic period luminosity curve. In the same year the first accurate value of the distance of the Large Cloud was published by Shapley (*H.C.* 268), to wit: 112,300 light-years.

Subsequent work as to the value of the zero-point of the period luminosity curve has but little changed the distances of the Clouds. It is outside the scope of this report to give a detailed account of recent work as to the zero-point determination in the distance-scale when dealing with exceedingly distant objects, but attention will be called to the possible existence of a differential absorption correction which will probably wipe out the zero-point correction of $+ 0^{m}{\cdot}6$ suggested from recent work by H. Nordström (*Lund Circ.* No. 4, 1931); B. P. Gerasimovič (*A.J.* **41**, 14, 1931); A. Kipper (*A.N.* **241**, 248, 1931); A. Fletcher (*M.N.* **92**, 780, 1932), and others. For a discussion at length the reader is referred to the mentioned papers and to a paper by Lundmark (*Medd. fr. Lund Astr. Observ.* Ser. II, Nr. 60, 1931).

In 1931 a new series of Harvard investigations as to the Clouds was started in *H.B.* 881. The structure of the Large Cloud was surveyed and the frequency of absolute magnitudes in different sections of the Cloud was derived on the basis of star counts including 57,391 stars. It was found that, if B (M) denotes the number of stars brighter than absolute magnitude M, B (− 2) = 26,170 and B (0) = 214,000. The general luminosity curve for the whole cloud can be represented with fair accuracy by the relation:

$$\log B\,(M) = 5{\cdot}0 + 0{\cdot}43\ M.$$

This compares with the corresponding curve for the Small Cloud (*H.C.* 260, 1924):

$$\log B\,(M) = 2{\cdot}89 + 0{\cdot}54\ M - 0{\cdot}18\ M^2.$$

The later result has not the accuracy of the former because of the wide deviations from the mean distribution in various parts of the Cloud. The galactic clusters of the Large Cloud are discussed in *H.B.* 884.

A discussion now in the press (*Lund Observ. Circ.* No. 8) based on the material of H. Shapley and Harvia Wilson as to 108 gaseous nebulae in the Small Cloud (*H.C.* 275, 1924) gives a fairly definite relation between the linear dimensions and the total magnitudes of the nebulae as well as between the linear dimensions and the absolute magnitudes of the exciting stars, which confirms the theory of Hubble as to the source of light in galactic nebulae.

The work by Hubble as to the distances of N.G.C. 6822 and 598, the former an irregular nebula and the latter a "late spiral," was performed prior to 1928. Doubtless cepheids and more of the ordinary type will be found in other stellar systems also, but it can be safely concluded that it will not be in many until there are instruments of higher light-gathering power than the Hooker telescope. The discovery by Hubble of irregular variable stars in N.G.C. 2403, 3031 and 5457 provides new possibilities of determining accurate distances for these objects. Work has been started at the observatory at Lund in order to derive the mean absolute magnitudes of galactic irregular variables. Miss Frida Palmer has recently published the first investigation to that effect, namely a catalogue of some 80 proper motions, newly determined or improved by her meridian observations. The spatial distribution of irregular variables and their mean absolute magnitude, and a discussion of the general properties of these stars, will be the subject for a forthcoming work.

For the present, it seems that we are restricted to determining the accurate distances of, say, at most a dozen outside stellar systems. But there is another method which will enable us to obtain distances of some 200 galaxies, the study of the brightest supergiants in the anagalactic systems.

Inquiries as to what happens when we photograph a stellar system under conditions which enable us to see just a few of the brightest stars projected upon the nebulous background of scores of undissolved stars have shown that the following corrections enter:

(1) The *veil correction* being the result of the additional intensity given to a very faint star by the chemical fog, the light of the sky and the light of the nebulous background.

(2) The *agglomeration correction* caused by optical pairs in a distant stellar system and to a smaller extent by binaries among the dissolved stars.

(3) The *absorption correction* caused by the fact that some of the stars are seen behind dark nebulae or absorbing regions.

(4) The *statistical dispersion correction* due to the stars not having actually constant magnitudes.

To these should also be added the *neighbourhood correction* discovered by G. Eberhard and making the photographic opacity and hence the brightness of an object on a photographic plate dependent upon the total light impressed upon the plate. The recent results by Walenkov indicate that the importance of this effect may have been many times overestimated, but still it should be investigated and considered further.

The detailed study of the systems in which dissolved stars have been found opens a wide field of investigation. In fact every case presents its special problems and calls for detailed investigations. Some of these have necessarily to be abandoned until we have the 200-inch, but a good many of the systems in question can be advantageously investigated by present means. Even 60-inch reflectors will do, and also long exposures with refractors of the Allegheny Thaw type will certainly prove to be useful in some cases for photometry of supergiants in anagalactic systems.

Until we have such refinements, estimates of the apparent magnitudes of dissolved stars will provide fair distances of the anagalactic objects included within the 10^7 light-year sphere. Preliminary work at Upsala (*Upsala Medd.* No. 38) indicated the following dispersion in the total absolute magnitude for individual classes of spirals:

Class of anagalactic objects	Mg.	Dispersion in Mg.	No. of objects
Globulars and ellipsoidal	$-13^{m}\cdot 7$	$\pm 1^{m}\cdot 45$	6
Andromeda type: patched arms	$-16^{m}\cdot 9$	$\pm 0^{m}\cdot 72$	4
Andromeda type: continuous arms	$-17^{m}\cdot 2$	$\pm 0^{m}\cdot 52$	5
Late spirals	$-16^{m}\cdot 0$	$\pm 0^{m}\cdot 57$	8
Magellanic Cloud type	$-15^{m}\cdot 2$	$\pm 1^{m}\cdot 40$	9

The dispersion is considerable only in the first and last groups. Recent work suggests the possibility of diminishing the dispersion when more material is available. It will then be possible to derive distances for distant nebulae with fair accuracy.

The clusters of galaxies present another possibility of deriving distances of exceedingly distant objects in the metagalaxy. Reference is made to the discovery and studies of different clusters by Shapley (*H.B.* 880); Carpenter (*P.A.S.P.* **43**, 247); Hubble (*Mt Wilson Contr.* 427, 1931); Christie (*Mt Wilson Contr.* 427, *P.A.S.P.* **43**, 350, 1931); Baade (*A. N. Mitt. d. Hamburger Sternwarte in Bergedorf*, **6**, 98, 1928, and *A.N.* **243**, 107, 1931); and Lundmark (*Lund Observ. Circ.* No. 227, 1931).

Work by Bernheimer and Lundmark has revealed a number of more than 200 clusters, the nuclei of which can be traced in most cases in the N.G.C. material. In fact, dealing with the brighter anagalactic nebulae, it is really difficult to find fields presenting a uniform distribution of objects. The clustering tendency is a prevailing feature. Some 2000 objects of the 7480 included in the N.G.C. are presumably members of metagalactic clusters.

It would not be fair to avoid mentioning a result that does not conform to the results mentioned above. In the last report from Mt Wilson (1930–1), Van Maanen has given the results of his determinations of proper motions of the nuclei of twelve spiral nebulae. The proper motions in right ascension range between $0''\cdot002$ and $0''\cdot0014$, and those in declination between $0''\cdot000$ and $0''\cdot019$. Thus a mean total μ of $0''\cdot011$ can be assumed. Various ways of determining the mean parallax of the objects in question lead to distances which are at least seventy times smaller than those derived from variable or non-variable stars. It is quite impossible to derive a disparity in luminosity and distance of anagalactic objects which can unite the two different results. It seems not very likely that we shall have to give up the photometric distances, and accept the ones resulting from the measures of Van Maanen, but it may well be that his measures will contribute to the discovery of some important hitherto unknown phenomenon. It has so many times happened in the history of the sciences that the "residual-phenomena" have furnished the means for remarkable discoveries.

(*b*) *Velocity-distance relation among anagalactic nebulae*. The discovery of this relation marks another important landmark in the developments since 1928. It can be traced back to 1925 when Lundmark presented the results of computations of the Apex on the basis of 44 radial velocities of anagalactic objects. The K-term was taken as varying with distance and the favoured solution had the form:

$$K = 513 + 4\cdot89r - 0\cdot0025r^2,$$

where r is the distance in Andromeda units (10^6 light-years). The distances were mainly derived on the basis of total magnitude and linear dimensions, and Hubble's solution in 1929 based on the distances of 25 objects derived from the dissolved stars marked a decided improvement. Hubble took K as directly proportional to r. At the same time it was found by Pease and Humason that four nebulae in the cluster near the galactic pole had velocities varying between 5000 and 7900 k/s, much larger than any cosmic velocity measured before. The 100-inch was assigned to an extensive programme and in 1931 Humason published results of measuring the apparent velocity shift of the spectral lines of 46 anagalactic nebulae of which nine had been observed by Pease (*Mt Wilson Contr.* No. 426). In a subsequent paper (*Mt Wilson Contr.* No. 427) Hubble and Humason investigated the velocity-distance relation. It was found that the relation had the following form:

$$\text{Distance in light-years} = 5830\,V,$$

where V is the radial velocity.

Work has been started for examining the form of the above relation on the basis of improved distances. It seems that the preliminary result, indicating a non-linear relation, still holds good. When analyzing the radial velocities, it will also be necessary to take account of the correlation between velocity and apparent dimensions, and between velocity and galactic latitude and between velocity and evolution in spectral class or nebular type.

Whatever is the final form of the velocity-distance relation, it is evident that it will be used with advantage for deriving distances of anagalactic clusters. The most accurate results will be obtained from distant objects—a circumstance of much importance.

(*c*) *Forms and structure of spiral nebulae.* Among theoretical works along this line attention should be given to those of Brown, Lindblad, and Vogt. The first-mentioned investigator (*Observ.* **51**, 271, 1926) has extended earlier work (*Ap. J.* **61**, 97, 1925) in which he outlined a gravitational system which was devised mainly for the apparent internal motions in certain spiral nebulae, which had been measured and discussed by Van Maanen. He considers lens-shaped aggregates of stars whose motions are governed by the Newtonian laws and which by approach and passage disturb one another by a kind of tidal force. Lindblad (*Stockholm Medd.* No. 3, 1930) started from his earlier work concerning the differential rotation of the galactic system. The explanation of the spiral form rests on the observation that orbits of high angular momentum in the principal plane of symmetry of the nebulae may be stable inside the nebulae, but unstable immediately outside it. The system with stable orbits defines the mother-system and the equation for the orbit of a star in the equatorial plane is established. A disturbing force exercised from another spiral accounts for the formation of the spiral arms. The most important conclusion to be drawn is in a certain sense periodical. The matter in the arms and the system may in most cases reorganize itself into a closed formation when the disturbing field has disappeared.

Vogt has in two papers (*A.N.* **242**, 181, 1931, and *A.N.* **243**, 405, 1931) established the theory that the cosmical repulsion indicated by the velocity-distance relation explains the formation of the spiral arms.

Even within this field co-operative work is certainly needed. When we begin to know something about distribution of stellar masses in anagalactic systems, the orbital motions within these can be computed using the methods of numerical integration.

(*d*) *Photometric investigations.* Among the contributions in this field, we have two very extensive ones; the first by the late Adelaide Ames giving total magnitudes in 2778 nebulae including the Virgo Cloud of galaxies and the second by H. Shapley and A. Ames being a survey of anagalactic systems having a total magnitude brighter than 13·0 containing 1249 objects (*Harv. Ann.* **88**, Nos. 1, 2, 1930, 1931). The method consists in using plates picturing the nebulae on the smallest possible scale in order to have them as starlike as possible. The nebular images were then compared with stellar images the magnitude of which were known from sequencies.

The magnitudes in the first catalogue have been used by Shapley and Miss Ames for extensive studies as to the relationship between different characteristics of nebulae and the distance and construction of three Virgo Clouds of galaxies (*H.B.* 864, 865, 866, 868, 869, and 887).

During stays at Mt Wilson and Lick Observatories in 1929, Lundmark was able to study the plates on file of nebulae and clusters. For every plate, objects presumably nebulae were marked and the total magnitudes for some 6500 nebulae were estimated.

https://doi.org/10.1017/S0251107X00016540 Published online by Cambridge University Press

A few words should be added as to our aim when estimating total magnitudes. We are not aiming at $0^m{\cdot}01$ or even at $0^m{\cdot}1$, but at $0^m{\cdot}3$ or $0^m{\cdot}4$. There are some who think that we had better wait for accurate photometry. In this connection it is good news that Stebbins is going to apply photoelectric photometry to the determination of total magnitudes.

A valuable contribution as to the distribution of the light in elliptical nebulae has been given by Hubble (*Ap. J.* **71**, 231, 1930). For fifteen elliptical nebulae it was found that the light was distributed according to the law:

$$\log T = \log T_0 - 2 \log (r + a)\, a^{-1},$$

where T is the surface intensity, T_0 is the central intensity of the nebula, r the distance from the nucleus, and a the distance where the luminosity falls off to $T_0/4$. By the process of integration the total magnitudes are derived in two ways.

It is scarcely necessary to point out the enormously wide field of research available even for humble instrumental means when total magnitudes are aimed at, and also that when plates can be obtained making it possible to apply strict photometric methods it is a duty to obtain such plates. It is only when the plates have been already taken for other purposes that the more crude methods of determining the total magnitudes should be applied.

Comparatively little has been done to advance our knowledge of visual magnitudes of anagalactic objects. There are a few small sets of magnitudes to be noted, but nothing very extensive. The question of the relation between the visual total magnitudes of Holetschek and the international scale has been discussed by Bernheimer in a series of papers (*Lund Circ.* 5, 6, 10). He finds that the correction to the Holetschek magnitudes suggested by Hopmann (*A.N.* **214**, 425, 1921) and generally taken as + 1·1 below 9·6 is not warranted. It so happens that the magnitudes of Holetschek without reduction follow rather closely the Harvard Scale. Some other circumstances also substantiate this conclusion.

(*e*) *Catalogues of nebulae.* The extensive work by K. Reinmuth, "Die Herschel-Nebel nach Aufnahmen der Königstuhl Sternwarte" (*Veroff. d. Badischen Sternwarte zu Heidelberg*, **9**, 1926), should be mentioned although issued two years before the last meeting of the I.A.U. Descriptions are given for 6251 objects. Although magnitudes have not been estimated, but the brightness given in Herschelian symbols, the uniformity of the work makes them by no means worthless. It is to be regretted that only objects observed by Herschel have been measured on the plates. A survey of the plates for all nebulae they contain is badly needed, and it is understood that Reinmuth intends such a survey. Reinmuth has also published a catalogue giving accurate positions for altogether 1236 nuclei of anagalactic objects (*Königstuhl Veroff.* **8**, Nos. 7, 12, 14, 17, 1927–32). Such measures should be welcomed, not because they give any means for deriving proper motions, but because the nuclei of the anagalactic objects are the only fixed points of reference there are in the Universe. Now that there are no longer any fixed stars, the system of reference should be moved from the stellar system and out into the metagalactic system.

Max Wolf published in 1929 his list of nebulae No. 16 containing mean places, descriptions, and photometric comparisons of 700 nebulae in the vicinity of the Northern Milky Way Pole. This contribution adds immensely to the 4834 objects observed by Wolf in his lists 1–15.

A list of W. Baade (*A.N.* **243**, 303, 1931) is of interest as giving descriptions and classifications of 65 objects on the basis of plates secured with the Hamburg Bergedorf 39-inch telescope.

A uniform and very extensive visual revision of N.G.C. objects is given in Hagen's

https://doi.org/10.1017/S0251107X00016540 Published online by Cambridge University Press

Durchmusterung of nebulae. The general catalogue uniting the results of the zone catalogues appeared in 1928 as *Specola Astronomica Vaticana* **13**, under the name of Fr. Becker. The most important data in the catalogue are, no doubt, the dimensions of the objects and their brightness. It embraces some 4000 objects. During the course of the preparation work for the Lund General Catalogue the catalogue has been statistically evaluated (*Lund Circ.* No. 3, 1931).

Here also is a field for co-operation. It will be sufficient to say that working with the measured radial velocities of nebulae, it has happened now and then that descriptive data on the basis of large-scale photographs have been difficult or impossible to obtain from existing collections. It is only five years ago that H. Shapley found an unrecorded gaseous nebula, having a mean diameter of 150′ (*Harv. Bull.* 843, 1927) and but little longer since Melotte and Lundmark found several extended gaseous nebulae on the Franklin Adams plates and an irregular nebula (*M.N.* **86**, 636, 1925), measuring 10′ × 2′·5 and very much like N.G.C. 6822.

(*f*) *A new general catalogue of nebulae and clusters.* The work for preparing a new general catalogue for nebulae and clusters is progressing steadily. The catalogue, which is intended to contain some 50,000 objects will be divided into two parts: (*a*) the index catalogue, and (*b*) the source catalogue containing all available information concerning nebulae.

(*g*) *Special problems.* The measurements of effective wave-lengths for faint anagalactic nebulae on the basis of long-exposure plates taken with the 60-inch telescope in 1922–3 have progressed but little since the last meeting on account of the lack of a good measuring machine at Lund Observatory.

An interesting contribution as to the distribution of colour in two anagalactic nebulae (M 51 and M 82) had been given by E. F. Carpenter using a method invented by himself. In the former case a strong continuous increase in blueness was found in passing outward along the arms from their base. The colour index was found to vary from $+ 0^{m}{\cdot}6$ near the nucleus to $- 0^{m}{\cdot}3$ about one revolution from the nucleus. In the latter case no essential difference between the blue and yellow images was found.

A new member of the scarce group of irregular nebulae has been discovered by Baade (*A.N.* **234**, 407, 1929).

Oort has discussed the distribution of the absolute magnitudes of anagalactic nebulae. He finds a considerable dispersion in the expression $m - 5 \log v$, where v is the radial velocity. If this dispersion is real, then the luminosity curve of isolated nebulae has not the same form as that derived from cluster data, or our galactic system is part of a local concentration of galaxies.

The masses and mass-ratios of anagalactic nebulae have been discussed in various papers by Lundmark (*Upsala Medd.* No. 40, 1928; *Pop. Astr.*; *Tidskrift*, etc.). A method has been devised for deriving the mass-ratio in the case of double nebulae but could not be tested out as yet on account of not having access to large instruments.

B. Galactic Nebulae

(*a*) *Dark nebulae.* Our knowledge concerning dark nebulae and other dark masses in the Universe has advanced considerably during recent years.

The Rassegna by Hagen and Becker has already been mentioned. This survey was intended to grade the bright nebulae as well as the dark ones, and the results as to the degree of darkness in the obscure nebulae are given in the catalogue in Roman figures from I to V. When the observations of Hagen were first announced, many students of nebulae took up a rather critical attitude. The faith in the power of the photographic methods was very great at the time, and visual observing had become more and more unpopular.

In connection with his observing of obscuring nebulae, Hagen also turned his attention to 52 diffuse nebulosities discovered by W. Herschel during his sweeps in 1783–1802. These fields had been photographed by Dr Roberts who found diffused nebulosity in only four regions. Hagen was able to see what early photography had not revealed, but it is quite natural that astronomers were quite hesitant. Hubble certainly expressed a wide-spread opinion among astronomers when he said at the Leiden meeting that, in his opinion, the crucial test regarding the existence of Herschel's nebulous fields would be the photographic survey of these fields by means of visual colour filters. Writing on the significance of Baxendell's nebulosity N.G.C. 7088 Hagen asked if this object the existence of which is so well assured by experienced observers but which has not hitherto been photographed may not present itself as a crucial test for what our present photographic skill is able to accomplish.

Independent observations of Herschel's nebulosities have been made by de Kerolyr observing at Forcalquier, Basses-Alpes, France. He had no difficulties in recognizing the nebulosities and describes them as faintly luminous and fog-like, or like greyish clouds, sometimes of a brownish tint. An uninformed observer seeing them for the first time in the field of his telescope would take them for terrestrial clouds. De Kerolyr (*Nouv. Observ. vis. et étude photographique de* 52 *Nébulosités étendues et diffuses de W. Herschel*, 1931) has also photographed diffuse nebulosities in some of the fields.

Several contributions have been made to the matter of the possibility of photographing the cosmic clouds by Hagen. Hopmann (*A.N.* **233**, 285, 1930) has discussed the general photographic problem of photographing faint extensive nebulosities, and Stobbe has discussed (*Z.f. Astrophys.* **2**, 182, 1931) under what conditions extensive surface objects of different colours can be photographed. Finally, K. Haidrich (*A.N.* **214**, 397, 1931) has succeeded in showing distinct veils of nebulosities in regions which were hitherto considered free from nebulosity. On the other hand it cannot be decided as yet with certainty if these are of the same type as Herschel's obscure clouds.

The final confirmation of Hagen's observations of obscure cosmic clouds has perhaps not yet arrived. But it seems that their reality can scarcely be doubted any longer. The fact that present methods of photography have not been able to confirm the existence of the clouds to more than a small extent does not mean that this situation will remain very long unchanged. We certainly can look forward to such improvements in the technical part of photography as will give us means to picture the greyish-brownish clouds first seen and recognized by the ardent observer, Hagen.

Melotte is revising the survey of the Franklin-Adams plates for dark nebulae made by him and Lundmark some years ago. It is intended to publish an extensive catalogue giving the results.

It seems that we may have at least three different kinds of dark nebulae, to wit: (1) Hagen's obscure clouds; (2) the dark nebulae revealed by photography; (3) the detached Calcium clouds, mainly studied by O. Struve. The first kind we cannot very well picture by photography as yet, and the same applies to the third kind. The relationship between the three classes of dark nebulae or cosmic cloud is really somewhat obscure so far. But the rapid progress within this vast domain of nebular

https://doi.org/10.1017/S0251107X00016540 Published online by Cambridge University Press

astronomy brings us the hope that it will not be long before we know much more about these peculiar and interesting objects and their kinship.

(*b*) *Bright gaseous nebulae and planetaries.* One of the most important contributions within this field has been made by Zanstra who has proceeded by applying the mechanism of ionization of nebular atoms by ultra-violet starlight and subsequent re-combination of photo-electrons, and that of electron excitation by photo-electrons freed by the former mechanism. This is applicable to the spectra of *H*, *He* I and *He* II in particular. Then the temperature is derived from the difference between the luminosity of the central star and the total luminosity of the nebula. The absolute magnitude of planetaries is derived from the rotation-term in the radial velocities. The temperature scale of Zanstra has been confirmed by Berman (*Lick Bull.* No. 430, 1931) who applied the law of Planck to the continuous spectrum of the central star. Vorontsov-Veliaminov has used the intensities of Wright and derived from them the temperatures of the central stars.

The parallaxes of Zanstra confirm the conclusions reached by Gerasimovič in 1927 from a discussion of various methods of distance determination that the average magnitude of the central stars is + 3·5. An entirely astrophysical method for deriving parallaxes of planetaries has been developed by Menzel (*P.A.S.P.* **43**, 334, 1931). The studies of the fine structure of the planetaries introduced by Berman open a very fascinating field.

KNUT LUNDMARK

Acting President of the Commission