34. COMMISSION DE LA MATIERE INTERSTELLAIRE ET LES NEBULEUSES GALACTIQUES

PRÉSIDENT: M. STRUVE.

MEMBRES: MM. Adams, Ambartsumian, Baade, Beals, Bertaud, Bok, Bowen, Cernuschi, Dufay, Dunham, Greenstein, Gurzadian, Hall, Haro, Henyey, Hiltner, Kharadze, Lambrecht, McKellar, Malmquist, Menzel, P W Merrill, Minkowski, Öhman, Oort, Parenago, Schalén, Shajn, V M. Slipher, Sobolev, Spitzer, Stebbins, Strömgren, Swings, ter Haar, Trumpler, van de Hulst, Vorontsov-Velyaminov, Whipple, Whitford, O. C. Wilson, W. H. Wright, Zanstra.

It happens once in a very long time that an entire branch of research is suddenly and unexpectedly revolutionized through a single discovery. Such a discovery was made, during the past three years, by W A. Hiltner and J. S. Hall, when they found that the light of distant stars is plane polarized and that the degree of polarization increases with the distance of the objects observed. Actually, the amount of polarization of the most distant stars (7·2% for the 6·9 mag., B9-type star HD 183143) could have been discovered even by photographic means. In fact, such a procedure has been instituted at the U.S. Naval Observatory by W Markowitz, who uses the 26-inch refractor and a thin calcite plate which forms two similar images polarized in perpendicular directions. In this manner stars to apparent magnitude 16 can be reached, and advantage can be taken of the large photographic field. Attention is also directed to B. Lyot's photo-electric polarimeter in which two photomultipliers are used to measure simultaneously two images of the same star.

Astronomers had made tests for the polarization of star light some thirty or more years ago. The results were, of course, negative because only bright, nearby stars were observed. Thereafter, no one for a long time seemed to take this question seriously. No one, except Y Öhman, whose valuable experiments on the polarization effects of special features in such objects as β Lyrae, the extragalactic nebulae, etc., kept alive this branch of knowledge. In this connection, attention may be directed to the recent publication of a volume by Öhman on *Polarization Measurements in Astronomy*, constituting a series of lectures delivered in 1949 at the High Altitude Observatory in Boulder, Colorado.

The observational results thus far obtained by Hiltner are contained in several papers in the *Ap. J* A large number of observations which he obtained at McDonald in September and October, 1950, and which include many O and B supergiants, a number of eclipsing variables, Cepheids and other intrinsic variables, are still in the 'raw' state at the time of this writing.

Hall's work on 551 stars, made with the 40-inch Ritchie-Chrétien telescope of the U.S. Naval Observatory, has been published in Vol. **17**, part 1 (1950) of the *Publications* of this Observatory. Reporting for this Commission upon his most recent work, Dr Hall writes:

Since finishing work on *Publications of the U.S. Naval Observatory*, Vol. **17**, part 1, I have been making polarization measurements on:

(1) Bright early-type stars observed by Dr Adams at Mount Wilson. Previous data indicate that pairs of stars 'close' together having similar interstellar line structure also show similar polarization. Examples are HD 24398–24534, 147888–147933, 176818–176819, 185859–188001, 190918–+35° 3955. More than 100 bright stars have been recently observed; many show no measurable polarization but the number of hits seems to justify the effort. β Lyrae is polarized 0·9%, $\theta=71°$; I hope to make quite a number of observations of this system.

(2) Fainter early-type stars, selected from any one of a number of lists, in order to fill in the gaps in Figure 4 of the paper mentioned above. One of these stars, BD +23° 3745, appears polarized 8·0% at position angle $\theta=116°$

(3) Reflection nebulae. Thus far only the Orion nebula has been observed. It is polarized up to 4% and the planes of polarization seem always to point toward the trapezium as the source of light.

In addition to the above a number of stars in the Pleiades were observed at the suggestion of Binnendijk. Binnendijk's reddened A0 star No. 371 is polarized 2·3% at $\theta = 122°$ One other star near it may also show polarization. This result suggests that the Pleiades nebulosity is a part of the Taurus cloud and that polarization can be a local affair caused by a very small cloud or portion of a cloud.

With reference to the polarization of the light of reflection nebulae, attention is called to the photographic work of W T. Whitney and E. B. Weston on NGC 6729, which follows the procedure used previously by Struve, and others. Hall has observed the polarization of the Orion nebula and has found a pronounced radial effect: 'the entire nebula is dominated by HD 37022; of secondary importance is HD 37041, polarization seems to increase with distance from the source; emission lines tend to dilute it; the two stars have small polarization: 0·3 and 0·5%.'

Still in connection with the observational problems of interstellar polarization, Hall submits the following recommendations to this Commission:

(1) The classical definition of the degree of polarization (*Naval Obs. Publs.* Vol. **17**, part 1, p. 12) should be used. A completely polarized star is then 100% polarized. For small values of polarization (less than 1%) two figures will be necessary with improved techniques. This definition is that used by Lyot, Öhman and such a well-known text-book as Jenkins and White.

(2) The term *plane of polarization*, defined by the magnetic vector and the line of sight, be used. It is probable that the polarizing particles are aligned parallel to the plane of polarization. Also, in doing work on reflection nebulae it is convenient to have the 'vectors' point to the source of light.

In designating the plane of polarization we have used the angular interval of 0 to 180° This seemed simpler than 90° to 270° or 180° to 360°

It might not be out of place to suggest that the plane of polarization be given in both the equatorial and galactic systems.

Hiltner, on the other hand, prefers to have polarization expressed in magnitudes which 'is the physically significant quantity (see van de Hulst, *Ap. J* **112**, 1, 1950)' For the plane of polarization he recommends 'the plane of vibration which, of course, refers to the physically significant electric vector' He adds that there is no reason 'why one should be handicapped by convention set by men who did not understand polarization of light'

H. Zanstra agrees that 'for work on polarization in general it seems desirable to use the plane of vibration passing through the electric vector and the line of sight' However, for special investigations Hall's recommendation could be adopted, provided that 'capitals be used as suffixes for the plane of vibration, I_R and I_T designating intensities for radial and tangential vibrations, while the plane of polarization could be specified by I_r and I_t'

On the theoretical side there have been many interesting developments, among which the following may be noted here:

(1) J. L. Greenstein and L. Davis, Jr., explain the polarization as the result of a preferential orientation of elongated interstellar grains in large-scale magnetic fields of 10^{-5} to 10^{-4} gauss, with magnetic lines of force predominantly in the galactic plane, and possibly along a spiral arm of dust, gas and B stars. Dr Greenstein writes:

The physical mechanism for orientation is based on the torque exerted on a paramagnetic substance when it spins in an external magnetic field. High frequency paramagnetic-relaxation energy dissipation has been found to be quite large in many common compounds of metals; abundance of iron is sufficient to make the composite grains paramagnetic. The lag of internal magnetization behind the field produces an energy dissipation resulting in a torque; while precessing and nutating the approach of the axis of rotation of the particle to parallelism to the field is counteracted by random collisions with gas. In a steady state a substantial degree of orientation of axes of the grains may be attained, even with a gas temperature of 10,000°, with a field of 5×10^{-5} gauss. The grains are left in rapid spin about the short axis which is parallel to the lines of force.

https://doi.org/10.1017/S0251107X00032582 Published online by Cambridge University Press

One difficulty faced by the theory is the lack of knowledge of the composition of the small grains. In this connection I urge the importance of the laboratory identification of the diffuse interstellar bands, which seem to be somewhat correlated with polarization. Another difficulty consists in the absence of computations of the extinction produced by elongated grains with radii near the wave-length of light.

If the magnetic field in space is of the order of that required by our theory, or by that of Spitzer and Tukey, many new important problems arise connected with interstellar matter. For example, I have suggested that the peculiarities of the T Tauri variable stars are caused by the infall of gas carrying with it a magnetic field. This field may trigger flare activity in the star, thus explaining the broad high-excitation emission lines found near those late-type dwarfs. Another effect of a magnetic field may perhaps be seen in the complex filamentary shapes of diffuse nebulae (perhaps even of planetary nebulae) and of the knots, lanes and shock-wave sharp structures seen in dark matter in the Milky Way. A link between theories of turbulence and magnetism is much to be desired.

(2) H. C. van de Hulst reports:

The illusion that the work on the laws of interstellar absorption had been brought to a close was shattered by the discovery of interstellar polarization. Though I tried to find different explanations, it seems that extinction by small oriented grains is the only explanation for this phenomenon. My work then was (*a*) the computation of extinction curves for different polarizations obtained if plane-polarized light falls perpendicularly on a very long circular cylinder. Refractive indices $m=\infty$, 1·5, 1·25, and close to 1, were used. A preliminary report was given at the Paris Symposium in 1949 and some further results published in *Ap. J* **112**, 1, 1950. An encouraging feature of the results was that a size of the diameters chosen to fit the dependence of total extinction on wave-length also gave the correct dependence of polarization on wave-length (the latter is nearly constant). However, the amount of polarization that was computed seemed rather small. For $m=1{\cdot}25$ long cylinders and perfect orientation were required to give the maximum amount that had been observed. Computations for complex m have since shown that absorbing particles give larger polarization ratios. (*b*) Needed for the work under (*a*) were a number of investigations of a more physical character about the scattering process. They are being collected and edited in a book on *Scattering by Small Particles*.

(3) L. Spitzer, Jr., and J. W Tukey suggest that an appreciable fraction of the solid interstellar dust particles, or grains, is elongated and ferro-magnetic. These grains are then oriented by the interstellar magnetic field postulated by E. Fermi in his theory of cosmic rays. A collision between two grains, each composed of ice, ammonia and methane, with some iron, might produce an iron particle, since the lighter constituents would boil off.

Turning now to other fields, we notice what is perhaps the first glimmer of a new era in the study of diffuse matter in the Universe. J. Stebbins and A. E. Whitford, in their work on the colours of extragalactic nebulae, find that some of their results 'may indicate the possibility of internebular material as compared with interstellar material'; and F Zwicky has also recently called attention to some diffuse-looking masses in the spaces between extragalactic nebulae, which may be individual stars or diffuse matter. Undoubtedly, this possibility of internebular material is now within the grasp of the largest telescopes. Continuing with the problem of interstellar absorption Whitford reached 'several stars with much greater colour excesses than those reported in my brief note in the *Astrophysical Journal*, **107**, 102, 1948. The reverse curvature in the infra-red is still there but is less prominent than that reported in the first note. Publication has been delayed by the need for better calibration of the lead-sulphide apparatus, but this should be completed in the next few months. On the basis of the present average curve, the ratio of total absorption to international colour excess is approximately 4·8.'

Along related lines, Öhman found departures from the $1/\lambda$ law in his study of the photo-electric colours of B stars; T Elvius and G. Larsson-Leander completed various

https://doi.org/10.1017/S0251107X00032582 Published online by Cambridge University Press

studies of interstellar reddening. C. Schalén 'studied two regions of the Milky Way (in Cygnus and Cepheus) the main purpose being to find out if the law of extinction is really the same in various parts of the Galaxy. Reddened B and A stars have been compared with stars of approximately the same spectral type which seem to have normal colour. The measurements seem to indicate that the extinction curves in Cepheus deviate from those in the Cygnus region.'

Problems of interstellar reddening have also been discussed by G. Alter who found that the selective absorption coefficients are not related to the galactic longitude, while the total absorption coefficients increase from centre to anti-centre regions. Dr Alter suggested that this may be caused by differences in the relative abundances of metals and carbon in different regions, and by a preponderance of small particles in the direction of the galactic centre.

An important contribution by Walraven at Leiden involves photo-electric colours of B and A stars, between 9 m. and 13 m. in Kapteyn's Selected Areas. Oosterhoff and Wesselink have determined the colour excesses of 350 O–B2 stars, south of $-40°$, while Walraven intends to study the B3 and B5 stars of the southern sky for colour excess, and plans also to determine the polarization of about 300 southern O–B2 stars.

At the Harvard Observatory B. J. Bok, Margaret Olmsted, and Betty D. Boutelle investigated the structure of the Milky Way at the junction of Gemini, Monoceros, and Orion. Dr Bok writes:

This study—based largely on photographically determined colour excesses of B and A stars—revealed rather surprising variations in interstellar absorption along the galactic equator. In the most transparent region studied, the average photographic absorption per kiloparsec was less than 0·5 mag. over the explored distance of 3000 parsecs, but in a relatively uniform appearing region only five degrees away in galactic longitude, the average total photographic absorption appears to be $2\frac{1}{2}$–3 times as large. This study is now being extended to greater distances using the photographically determined colour excesses (and possibly also photo-electric ones) for three distant cepheid variables in this section of the Milky Way, VW. VZ and WW Mon.

From the colour excesses of four faint cepheids in Cygnus we find a total photographic absorption of approximately 2 mag. at a distance of 8000 parsecs in gal. long. 43°, gal. lat. $+3°$

A study of the absorption characteristics of two sections of the southern Milky Way is an integral part of my project in South Africa. I have under investigation four centres in the Sagittarius-Scorpio section and three in the Carina-Crux section. The photographic plate material that has already been obtained with the 24-inch Bruce and 10-inch Metcalf telescopes is intended to provide magnitude and colour standards for these seven fields. To supplement this an extensive programme had been planned for the new Baker-Schmidt telescope. Photo-electric work on the colours of faint stars in these same fields has been started. The plans include work on O, B, A and C stars, and especially colour-studies of faint cluster-type variables and cepheids.

There is one further item that may be of interest to Commission 34. Jointly with R. H. Baker and Mrs S. D. Gossner, I am engaged in a project of providing a summary of the surface distributions of the stars and the absorption characteristics for all fields covered by the Ross-Calvert Atlas of the Milky Way. Mrs Gossner has finished the preparation of charts for each of the photographs in the atlas and the work of bringing together all the star count and colour data now available is well in hand.

On the theoretical side Aller made an attempt to determine the turbulence spectrum in the interstellar medium in Cygnus from a study of the intensity variations in bright nebulosity photographed with the large Palomar Schmidt telescope. There is some suggestion that the turbulence elements which contain most energy are several parsecs in diameter. The International Union of Theoretical and Applied Mechanics joined with the I.A.U. in organizing a symposium on 'Problems of Motion of Gaseous Masses of Cosmical Dimensions' which was held in Paris on August 16–19, 1949. The results of these discussions will be published *in extenso*.

B. Strömgren's extensive work on the density and distribution of the interstellar gas was published in the *Astrophysical Journal*, while L. Spitzer, Jr., assisted by Messrs Savedoff, Buscombe and Schapp, continued the investigation of the temperature of the interstellar gas.

Results yield a temperature of about 10,000° in H II regions, in rough agreement with the value from the observed ratio of [O II] $\lambda 3727$ to H_α. In H I regions, where the chief source of energy is gone with all H neutral, the temperature is reduced to about 60°; electron excitation of C^+ and Si^+ ions, inelastic encounters between H atoms and grains, and possibly also inelastic encounters between H atoms and H_2 molecules can all be important in holding the temperature down. A difference of temperature by a factor of about 100 between H I clouds and surrounding regions at higher temperature may account for a density difference of this order between the two types of regions, with the same gas pressure in each.

Bates and Spitzer have considered the abundance of CH and CH^+ molecules in interstellar space. An analysis of Adams' visual estimates indicates that two quite different physical situations must be considered. In stars of types O to B1 the molecular lines correlate with colour excess, and the molecules are presumably concentrated in H I clouds. The radial velocities of these clouds are generally negative with respect to the stars, a result of the K effect. Analysis of the equilibrium concentrations, taking into account improved values of the reaction rates, can account for the observed strength of CH^+ $\lambda 4232$, but the roughly equal strength of CH $\lambda 4300$ is difficult to explain. In stars of types B2–B8 the molecular lines appear in unreddened stars and the radial velocities in such cases are predominantly positive with respect to the stars. The molecules are presumably circumstellar and may be attributed to a hemispherical shell of CH_4 molecules evaporating from grains approaching to within half a parsec of the star. This model explains the observed velocity effect and accounts quantitatively for CH^+ $\lambda 4232$ but not for CH $\lambda 4300$.

A recent development of the utmost importance is the discovery by H. A. Ewen and E. M. Purcell of an interstellar emission line of hydrogen at a wave-length of 21 cm. This line is due to a hyperfine structure transition of the ground state of the neutral H atom. It arises from a transition between parallel and anti-parallel positions of the electron spin and proton spin. The existence of this line was predicted by van de Hulst in 1944 (*Nederl. Tijdschr. Natuurkunde*, **11**, 217, 1945, see also the remark concerning Shklovsky's independent, but presumably later, prediction on p. 525). Preliminary observations indicate that this line is strongest in Ophiuchus, and has a width of 50 k.c., corresponding to interstellar cloud velocities of the usual order. Van de Hulst writes in this connection: 'this discovery is extremely important because it opens for the first time the opportunity of observing interstellar hydrogen in the vast regions where it is un-ionized.'

Almost simultaneously this bright hydrogen line was also observed by C. A. Muller and J. H. Oort in the Netherlands. The width of the line suggests random velocities of 5 km./sec. in one co-ordinate. The emission is concentrated in a wide belt around the Milky Way, which implies that the radiating clouds are quite close to us: in the direction of the galactic centre their distance is not more than 300 or 400 parsecs. This may mean that the clouds become optically thick, within this line, at distances of 500 to 1000 parsecs. Because of the Doppler displacement produced by galactic rotation the radiating clouds can be observed at very great distances, in the appropriate galactic longitudes (for example, at 8 kiloparsecs in gal. long. = 355°, and with a frequency of the receiver 250 kc./sec. lower than that of the undisplaced line).

W. S. Adams has published his measurements of the interstellar H and K lines of Ca II, and of molecular lines, in 300 stars of classes O and B. Additional measurements of velocities and intensities of interstellar lines in 140 stars have been completed by C. S. Beals: and still further observations of faint O and B stars by J. A. Pearce and R. M. Petrie are in progress at Victoria. Valuable observational material on interstellar lines has been collected at Mount Wilson by R. F. Sanford and by L. Spitzer, Jr.

The physical problems in gaseous nebulae have been dealt with in several publications. The following summary on planetary nebulae was prepared by L. H. Aller, at the request of the Chairman:

Investigations by Minkowski have expanded the list of known planetaries to nearly 400. Most of the newly found objects lie in highly obscured regions. Many appear as remote as the galactic centre. The survey is being extended to the Southern Hemisphere. The Mount Wilson 10-inch telescope has been set up at the Lamont-Hussey Observatory of the University of Michigan at Bloemfontein, Orange Free State, where the observations are being secured by Karl Henize. The new data emphasize the strong concentration of the planetaries towards the central region of our galaxy. Apparently most, if not all, are objects of Baade's type II.

The most important advance in the study of the planetary nebulae has been Olin Wilson's investigation of their internal motions with the Coudé spectrograph of the 100-inch reflector. The most reliable expansion velocity is the mean of the values given by lines of H, [O III] and [Ne III]. Different ions often show different expansion velocities; the two components of the lines of high excitation ions show smaller separations than do the components of lines of low excitation ions. Extreme examples are provided by [Ne V] for which the line-splitting is often vanishingly small, and [O II] and [N II] which frequently show large separations. Hydrogen agrees closely with [O III] and [Ne III] thus providing an exception to the correlation between separation and excitation. Wilson also finds the component separation to be correlated with the monochromatic image size, although the differences in image size are usually smaller than differences in line-splittings. The forbidden lines are often sharp; the hydrogen lines are noticeably diffuse.

The most attractive interpretation of the observations is that the velocity given by the lines of any ion is a measure of the speed of the much more abundant hydrogen and helium in the particular region where the given lines are emitted. In this picture the material originally has a velocity equal to that measured for [Ne V] which is often as small as 5 km./sec. The gas absorbs radiation, and along with it the momentum carried by the radiation, and is gradually accelerated. Thus the increase in velocity between [Ne V] and He II and between He II and H results from the transfer of momentum to the gas upon absorption of radiation from the central star below λ228 A. and between λ912 and λ228 A. respectively. The observed velocity changes and nebular brightnesses lead, in this picture, to reasonable values for the radius and temperature of the nuclear star.

With the aid of an image rotator it is possible to secure excellent slitless spectrograms of small bright planetary nebulae at the Coudé focus of the 100-inch reflector. Such observations and direct photographs with the 200-inch reflector show a complexity of structure in even the most orderly appearing objects. Attempts have been made to derive the variation of the emission per unit volume with distance from the central star for a few of the most regular appearing objects. Spherical symmetry appears to be a crude zeroth order approximation in even the most favourable instances.

Spectroscopic studies have been carried out by a number of observers. The infra-red (H_α to λ8900) has been investigated by R. Minkowski and L. H. Aller and by P. Swings and P. D. Jose.

Spectrophotometric studies of a few bright nebulae in the region $\lambda\lambda$9000–3700 have been carried out by Minkowski and Aller to supplement data obtained for NGC 7027 ($\lambda\lambda$3300–9000) some years ago. L. H. Aller has completed the discussion of spectrophotometric observations of forty-five planetaries made at the Lick Observatory. After correction for space absorption, the observed Balmer decrement is found to agree with the theoretical predictions by Menzel and Baker for their model 'B', in which all Lyman radiation is assumed degraded into Lyman alpha which alone escapes from the nebula. M. L. White, at Michigan, has studied the [N II] lines in a number of representative objects.

On the theoretical side mention must be made of a number of papers on radiation processes in planetaries by D. H. Menzel and H. K. Sen in this country, and by Y. Hagihara, Y. Hatanaka, N. Soma, S. Miyamoto, and W. Unno in Japan. Of particular interest is the conclusion by the Japanese astronomers that the Lyman α radiation is not much larger than the ultra-violet

https://doi.org/10.1017/S0251107X00032582 Published online by Cambridge University Press

radiation but that in the outermost parts of an extended stellar atmosphere the Lyman α pressure becomes about 100 times larger than the ultra-violet radiation pressure. These investigations are closely related to some ideas previously developed by H. Zanstra.

The recent Palomar and Mount Wilson observations have emphasized the enormous complexity of the structure of the planetaries. They show neither a regularity which might permit an exact theoretical analysis nor the simplicity of complete chaos. The first approximation to their physical nature and structure, due to Bowen, Zanstra, Menzel, and others is relatively simple; the second approximation seems almost impossible. Future theoretical studies must take into account the motions as well as the distributions of the radiating gases.

Unfortunately, certain necessary atomic parameters, e.g. the target areas for the collisional excitation of the forbidden lines, cannot be calculated at present. Consequently, about all we can say concerning the chemical composition of the radiating gases is to reiterate the conclusion of Bowen and Wyse that the material appears to have the same chemical composition as the solar atmosphere.

Precise measurements of the surface brightnesses of the nebulae, and above all, good distance estimates, are needed.

Because of the great language barrier which prevents the complete utilization in western countries of important advances made in the Soviet Union and published there only in the Russian language, it seems best to present herewith a detailed account by E. K. Kharadze and V V Sobolev especially prepared by them in English for Commission 34:

Selective absorption. O. A. Melnikov deduced a mean colour excess of $0^m{\cdot}23$ per kiloparsec (*Publ. Pulkovo Obs.* Vol. **64**, 1950). E. E. Kharadze obtained a value of the colour excess per 1 k.p.s., largely depending upon the galactic latitude, from $0^m{\cdot}52$ in the galactic plane to $0^m{\cdot}06$ at the mean galactic latitude of 58° (*C.R. Acad. Sci. U.R.S.S.* Vol. **71**, no. 2, 1950). M. A. Vashakidze established the fact that the colour excess per 1 k.p.s. in the direction to the centre of the galaxy exceeds by $0^m{\cdot}11$ the colour excess in the direction to the anticentre. At the same time, in accordance with the results obtained by P P. Parenago and B. E. Markaryan, he confirmed the fact that the value obtained by Hubble for the optical thickness of the selectively absorbing galactic layer is slightly underrated.

General absorption. The lower limit of the general absorption per 1 k.p.s. has been estimated by Melnikov as $1^m{\cdot}1$ (*Pulkovo Publ.* Vol. **64**, 1950). Vashakidze and G. S. Badalyan (*Comm. Burakan Obs.* No. 3, 1949) determined, from cepheid colours, the general absorption to be $2^m{\cdot}0$. Kharadze (loc. cit.), according to the colour excesses of the faint stars in Kapteyn Selected Areas, has also found the value of the general absorption equal to $2^m{\cdot}0$. A. N. Deutsch (*Pulkovo Publ.* No. 138, 1947; No. 141, 1948) obtained, on the basis of an analysis of proper motions of a number of stars, the value of $1^m{\cdot}3$. G. A. Agekyan (*Sci. Papers of the Leningrad State University*, Vol. **18**, no. 116, 1949), on the basis of stars in the galactic plane, obtained a value of $1^m{\cdot}6$ per 1 k.p.s.

Relation of the selective and the general absorption. Vashakidze deduced a new formula for the calculation of the factor which transforms the colour excess into general absorption (*Bull. Abastumani Obs.* No. 13, 1951). The formula takes into consideration the change of the exponent of the wave-length in the law of absorption. The formula gives $\gamma = 4{\cdot}6$. Melnikov computed the lower limit of the factor after having determined the change of the exponent α along with the change of λ.

Neutral absorption. The neutral absorption determined by Vashakidze by means of a comparison of the data of counts of extragalactic nebulae (according to N. F. Florya's formula with that based on the colour excess of Stebbins and Kharadze) proved to be extremely irregular (for certain directions varying within the range of $0^m{\cdot}5$–$0^m{\cdot}0$) with an average of $0^m{\cdot}3$.

Dimensions of particles of the absorbing dust. Mie's theory was utilized in an analysis of the data of Melnikov (*Pulkovo Publ.* Vol. **64**, 1950) and Kharadze (*C.R. Acad. Sci. U.R.S.S.* Vol. **71**, no. 2, 1950). The former came to the conclusion that in the lower latitudes the dimensions of the particles of the interstellar matter causing selective absorption are of the order of 100 mm., whereas in the higher latitudes they are 50 mm. The latter proved that the size of the particles near the galactic plane was 10–15 % above the average, corresponding to the directions 27–72° of the galactic latitude.

V A. Ambartsumian (*C.R. Acad. Sci. U.R.S.S.* Vol. **44**, no. 6, 1944) deduced an equation which determines the function of the distribution of brightness of the Milky Way, on the basis of a conception that fluctuations in brightness are caused by the presence of clouds of dark matter. Recently Ambartsumian made a generalization of this work: equations have been obtained determining the fluctuations of partial brightnesses of the Milky Way, i.e. the brightnesses that are caused by the stars of a definite class. Ambartsumian (*A.J. U.S.S.R.* Vol. **23**, no. 5, 1946) also studied the surface brightnesses in the galaxy, produced by all the stars and by stars of various types. He demonstrated that stars possess a greater galactic concentration than the absorbing matter. He also drew the conclusion that the Sun is not located in the arm of the galaxy.

Characteristics of the Dark Clouds. The application of the fluctuation theory of the brightness of the Milky Way, mathematically developed by Ambartsumian, has provided new, independent estimates of the absorption of an average nebula ($0^{m}\cdot25$ according to G. I. Rusakov, *Sci. Notes of the Leningrad Univ.* No. 116, 1949; $0^{m}\cdot27$ according to S. T. Khabibulin, *A.J U.S.S.R.* Vol. **27**, no. 2, 1950). The number of dark clouds in one cubic kiloparsec, in Kharadze's estimate, is 10^{4}. The mass of an average nebula is of the order of the mass of the Sun (the theoretical estimate of G. G. Kuzmin, *Astronomical Almanac of the Tartu Obs.* 1948). The mass of all the interstellar dust in the galaxy is, in Kharadze's estimate, 10^{16}–$10^{7} M_{\odot}$. He has also obtained data pointing to: (1) arrangement of individual localized masses of dispersing matter not only at small, but also at large distances from the galactic equator; and (2) the general asymmetry of dark matter in relation to the galactic equator.

E. L. Ruskol (*A.J. U.S.S.R.* Vol. **27**, no. 6, 1950), having investigated the forms and the spatial orientation of the dark nebulae, confirmed the theoretical conclusions concerning the elongation of nebulae along the plane of the galaxy. She pointed out the existence of round, extremely non-transparent and exceedingly small (not larger than 0·1 parsec in radius) nebulae.

Polarization of diffuse nebulae. Vashakidze measured the polarization in diffuse nebulae: NGC 6514, NGC 6618, NGC 1976, NGC 1977, and in the Pleiades, and found respectively: 10, 8, 14, 7 and 12 % of polarized light (*Abastumani Bull.* No. 13, 1951). V A. Dombrovsky (*C.R. Acad. Sci. Armenian S.S.R.* No. 5, 1950) discovered that of all the stars tested in the constellation of Cepheus only one star (CQ Cephei) has polarization (the degree of polarization—6 %). This, apparently, indicates that polarization does not originate in interstellar space, but in the atmospheres of the stars.

The study of bright galactic nebulae. In 1949–50, by means of a large-aperture double camera of 460 mm. (F/1·4) in combination with two narrow-band filters (with the gap centre near H_{α} and outside of H_{α}), G. A. Shajn and V F. Gaze (*Crimean Publ.* Vol. **3**, 1950) studied a considerable number of photographs of bright diffuse nebulae. Double photographs make it possible to isolate the gas and dust components of bright nebulae. Up to forty new nebulae have been found. A study of the nebulae leads to the conclusion that in the majority of cases there is a genetic relation between gas nebulae and the stars associated with them. A special type of semi-regular bright nebulae was found, with a more or less symmetrical distribution of matter at the periphery. Attention has been paid to the study of the structural peculiarities (filaments, stratification, dark formations, globules). An investigation of the problem of the identity of various types of nebulae leads to the conclusion that the gas nebulae associated with O and B0 stars and gas-dust, or dust-reflecting nebulae associated with B2, B3, stars, cannot be considered identical at the present time, in spite of their close genetic interrelation. An investigation of selective and general absorption in areas of the sky occupied by bright nebulae is being projected.

S. B. Pikelner has begun a spectrophotometric investigation of diffuse nebulae, the source of excitation of which is unknown. It is intended to develop a theory of the luminosity of diffuse nebulae on the basis of the observations obtained.

Theoretical investigations. G. A. Gurzadyan (*A.J. U.S.S.R.* **26**, no. 2, 1949) investigated the gravitational equilibrium of the interstellar hydrogen. Only stars of spectral types earlier than B 5 influence the interstellar hydrogen at great distances, causing a disordered movement of the diffuse interstellar matter. Agekyan demonstrated that stars of high luminosity may be accelerated in passing through dust or hydrogen clouds, as the result of an interaction with interstellar matter.

Theoretical investigations of the dynamics of the interstellar dust matter were conducted by G. G. Kuzmin (*Astr. Almanac of the Tartu Obs.* 1948) who obtained a mean density in the plane of the galaxy of 2×10^{-26} g./cm.^{3} and in the average nebula of $0{\cdot}4 \times 10^{-24}$ g./cm.^{3}, as well as a mean residual velocity of the dust particles of 0·1 km./sec. P P Parenago (*A.J U.S.S.R.* **22**, no. 3, 1949) gave a map of the interstellar absorption of light in various areas of the sky, built on the basis of the determinations of the star colours and calculations of the numbers of extragalactic nebulae in these areas.

Parenago's theory of absorption. This theory of interstellar absorption has found a wide application. N. F Florya (*Sternb. Astr. Inst. Publ.* Vol. **16**, 1949) and Kharadze (*Bull. Abastumani Obs.* No. 12, 1951) made a determination of the parameter a_0 from observations and a comparison of the theoretical dependence of absorption on the distance with the dependence represented by observations. Good agreement of the observations with the theory for the majority of directions is obtained.

Absorption and the dimensions of clusters. P Parenago, B. Kukarkin and N. Florya (*Sternb. Astr. Inst. Publ.* Vol. **16**, 1949) found that linear diameters of globular clusters are the smaller the greater the colour excess. A similar result was obtained by K. A. Barkhatova (*A.J. U.S.S.R.* Vol. **26**, no. 4, 1949) for galactic star clusters.

Star counts. The theory of star counts to determine the light absorption received a further development: S. T. Khabibulin (*A.J U.S.S.R.* **26**, no. 4, 1950) demonstrated that the well-known Seeliger theorem takes place for counts in two wave-lengths: D. J. Martynov (*A.J U.S.S.R.* **26**, no. 4, 1950) pointed out the possibility of escaping this difficulty by estimating the absorption in determining star densities by means of photographs in two wave-lengths. In the same observatory, investigations of the dark areas in Cygnus have been undertaken by means of Ogorodnikov's method on the basis of star counts up to the 17th stellar magnitude.

Determination of star colours. At the Abastumani Observatory determinations of colour indices of faint stars up to $13^{m}{\cdot}5$ in Selected Areas Nos. 44–67 are continued with the purpose of investigating the interstellar absorption. At the same observatory a fundamental catalogue of photo-electric colour equivalents of approximately 1000 stars of spectral types B8 and B9 (V B. Nikonov) has been completed and colours of about 200 stars of high luminosity determined.

V V Sobolev (*Sci. Papers Leningrad Univ.* No. 82, 1941) investigated the energy balance of the free electrons of a nebula with the assumption that the electrons receive their energy during the photo-ionization of the hydrogen atoms and lose it in three ways: by radiation in a continuous spectrum, by collisions with ions O^{++} and by collisions with atoms of hydrogen. Hence the method for the determination of the upper limit of the electron temperature of the nebula, as well as the lower limit of the nucleus temperature, was obtained.

Sobolev (*A.J. U.S.S.R.* **21**, no. 4, 1944) has also investigated the field of Lα radiation in a nebula expanding with a gradient of velocity, taking into account the re-distribution of the radiation according to the frequencies within the line, i.e. in non-coherent light scattering. He demonstrated that the light pressure depending upon the Lα-radiation plays a far smaller role than had previously been determined by Ambartsumian and Zanstra, who admitted coherent scattering.

B. A. Vorontsov-Velyaminov published a monograph, *Gas Nebulae and New Stars* (1948), in which he gave a detailed critical summary of all the available theoretical and observational data on gas nebulae. The author's many years of work in this field were also summed up. For example, the hypothesis of the accumulation of gas matter in the galaxy on account of its bursts from stars is developed in detail. The monograph contains a catalogue of 288 planetary nebulae and as a whole is a valuable reference book in this field. Proceeding from observational data, Vorontsov-Velyaminov (*A.J. U.S.S.R.* **27**, no. 5, 1950) deduced the formula: $M_n = 0{\cdot}04 - 0{\cdot}22\ (M* - M_n)$, with the help of which the distances to the planetary nebulae and their dimensions have been determined.

O. A. Melnikov (*A.J U.S.S.R.* **24**, no. 2, 1947) constructed growth curves for interstellar gas using the lines Ca II and Na I. It was found that the peculiar velocities of the clouds of interstellar gas were approximately equal to 7 km./sec.

P. P. Parenago (*A.J U.S.S.R.* **23**, no. 2, 1946), from the proper motions and radial velocities of planetary nebulae, determined their mean absolute photographic magnitude ($M_n = -0{\cdot}8$). Admitting that $M_n = \text{const.}$, the distribution of nebulae in the galaxy was found. An account of the absorption of light was made according to the data of the above mentioned work of Parenago on the interstellar absorption of light. V A. Dombrovsky (*Sci. Papers Leningrad Univ.* No. 136, 1950) worked out a method for the spectrophotometric study of nebulae. For NGC 224, a colour temperature has been obtained in relation to the distance from the nucleus. For various parts of the nebula NGC 1976, the distribution of energy in a continuous spectrum was found, also the relative intensities of emission lines and the ratio of the intensities of the lines and the intensity of the continuous spectrum.

A. A. Nikitin (*Sci. Papers Leningrad Univ.* No. 136, 1950) calculated the relative intensities of the emission lines of helium for the case of planetary nebulae. The concentration of the atoms of helium in the nebulae (on the average, 1/10 of the concentration of hydrogen atoms) was determined.

I. S. Shklovsky (*A.J U.S.S.R.* **25**, no. 4, 1948), in an article concerning radio radiation of the galaxy, demonstrated that radio radiation of the utmost intensity corresponds to those areas of the sky where the O-stars are located. This is explained by the existence of extensive zones of ionized hydrogen around hot stars. Fluctuations of the intensity of radio radiation are explained by 'splashes' of radio radiation on individual stars. In the article 'Monochromatic radiation of the galaxy and the possibility of its observation' (*A.J U.S.S.R.* **26**, no. 1, 1949) he demonstrated that a monochromatic radio radiation with a wave-length of 21 cm., which may be detected in observations, arises in transitions between the components of the hyperfine structure of the ground state of the interstellar hydrogen atoms.

Metagalactic absorption. M. S. Eigenson (*C.R. Acad. Sci. U.R.S.S.* Vol. **63**, 1948; *A.J U.S.S.R.* **26**, no. 5, 1949) confirmed the existence of a metagalactic absorption of light and demonstrated that the density of the dark metagalactic matter should amount to 10^{-26}–10^{-27} g./cm.^{3}; correspondingly, the mass must be 10^3–10^4 times the mass of a 'luminous metagalaxy' The estimated value of the general metagalactic absorption is about $0^{m}{\cdot}025$ per 1 m.parsec.

OTTO STRUVE
President of the Commission

RAPPORT SUPPLÉMENTAIRE

In 1951 G. A. Shajn and V F. Gaze undertook a series of photographic observations which led to the discovery of many new emission nebulosities, including one in the vicinity of η Geminorum. The result of their work has been printed in the *Publications of the Crimean Astrophysical Observatory* and also in the Russian *Astronomical Journal* and in the *Publications of the Academy of Sciences of the U.S.S.R.*

V G. Fesenkov has made a study of several gaseous nebulae, with the help of photographs obtained with a Maksutov telescope at Alma-Ata.

Finally, D. P Guk has obtained for the mass of the ω Nebula NGC 6618 a value of 515 times the mass of the Sun.

OTTO STRUVE

Further Additions to the Draft Report

(Recommended by the Commission on 8 September 1952.)

1. Prof. B. Vorontsov-Velyaminov calls attention to his own work on groups of hot super-giants in the Milky Way, which has led him to conclude that because of obscuration effects, the true dimensions of these groups are often much larger than the apparent ones. Estimates of luminosities of these stars, based upon the assumption of their

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vicinity in space, may lead to large errors, and may distort the resulting picture of the spiral structure of the Galaxy. Prof. Vorontsov-Velyaminov has found that the arrangement of the spiral arms differs substantially from that recently published in *Sky and Telescope*, which was based upon the diffuse nebulae.

2. Prof. H. Zanstra prepared the following summary: After Minkowski (*Ap. J* **95**, 243, 1942) had shown that, for many planetary nebulae of low surface brightness, the absorption of the ionizing ultra-violet radiation is probably complete, Wurm, in more recent years, has put forward evidence that the same thing applies to many planetary nebulae of high surface brightness (cf. K. Wurm and O. Singer, *Z. Ap.* **30**, 153, 1952). This has a very important bearing on most of the problems connected with planetary nebulae, in particular on the temperatures of the central stars.

Important work on southern nebulae has been presented within the last few years by Evans and Thackeray. These two authors (*M.N* **110**, 429, 1950) have given a photographic survey of twenty-six bright southern planetary nebulae, while Evans has carried out a careful photometry of the distribution of light in various colours for NGH 5128 and the planetary nebula IC 4406. Evans's results for the latter very remarkable object were discussed theoretically by Zanstra and Brandenburg (*B.A.N* **11**, no. 428, p. 350, 1951).

In *B.A.N.* **11**, no. 428, 1951, Zanstra discussed the concentration of neutral hydrogen in planetaries (p. 341), while de Jong treated the effective absorption coefficient and optical depth for neutral hydrogen, which presents a means of taking into account the frequency dependence for the absorption *Lc*. The treatment of non-coherent scattering for Maxwell distribution and resulting radiation pressure in a stationary nebula given in *B.A.N* no. 401 was extended by Zanstra so as to take into account the dependence of intensity on direction; for which case de Jong provided numerical results (*B.A.N* **11**, no. 429, p. 359, 1951).

3. Dr T. Gold requested that the following addition be presented.

The observations of the polarization of starlight have been taken to be an important indication of interstellar magnetic fields. It has now, however, been possible to find a purely dynamical cause for the alignment of interstellar dust particles. The relative velocity between dust and gas defines everywhere a direction in space. Such relative velocities will not die out so long as turbulence exists in the gas with a scale of the order of 10^{20} cm.

The spin of elongated dust particles is determined principally by collisions with gas molecules possessing a different bulk velocity. Therefore it is not surprising that a consideration of the dynamics shows an anisotropy of the distribution of elongated particles, such that the long dimension of the particles lives preferentially in the direction of the relative velocity.

The dynamical explanation would result in agreement with the observed polarization effects if it were assumed that the principal velocities of interpenetration occurred normal to the galactic plane, being associated with the oscillation of dust clouds through the central plane of the Galaxy.

An account of this work is in print for the *Monthly Notices, R.A.S.*

Report of meeting

PRESIDENT: Prof. O. STRUVE.

SECRETARY: Dr C. SCHALÉN.

The Commission passed the following resolutions:

(1) That polarization investigators give a proper definition of the symbols they use.

(2) In recent years some workers on nebulae and interstellar matter have deviated from the general practice of assigning roman figures to the spectrum (for instance He I, He II) and have used this notation for atoms or ions (for instance He I for neutral He, and He III for He^{++} or He^{2+}). Thus the region of a planetary nebula where the He I spectrum is emitted

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is now sometimes referred to as the He II region, meaning by this that the recombining ion He^+ is there predominant. This may easily lead to confusion. *It is resolved that it is not allowed to indicate a region by roman figures, unless the corresponding spectrum is emitted in this region.* Thus the region where the He I spectrum is emitted is to be termed the He I region or, alternatively, if this spectrum is produced by recombination, and the recombining ion He^+ is predominant, it may also be called He^+ region. *An exception can be made for interstellar hydrogen*, where there is no harm in using the term H I region for neutral H region and H II region for H^+ ion region, since the terms H I and H II are not used by spectroscopists who use H for the hydrogen spectrum. It is further resolved that, following the general practice of physicists, neutral atoms should be indicated by the chemical symbol (like H, He) and ions by a number of + or − signs (like H^+, He^+). However, there is no harm in using the spectral notation for an atom or ion, provided the spectrum is actually emitted. Thus, in the solar corona, the term Fe XIV ions may be used instead of Fe^{13+} ions when referring to a region where the Fe XIV spectrum is observed. Similarly, where the O III spectrum is emitted in a planetary nebula, one may speak either of O^{++} ions or O III ions, but in this region the term O IV ions is not allowed.

(3) To ask the Executive Committee to appoint a sub-committee in order to prepare a new catalogue of gaseous nebulae preferably with reproductions and including the southern hemisphere.

The following were appointed members of this committee: Shajn, Thackeray and Bok.

Communications

Photographies infra-rouges de la région du centre galactique par J. Dufay, J. H. Bigay, P Berthier et J. Texereau (presentée par J. Dufay). (Observatoires de Lyon et de Haute Provence.)

La région entourant le centre de la Voie Lactée a été photographiée avec un objectif de courte distance focale (F = 160 mm.), ouvert à F/2, avec le télescope Schmidt construit par J. H. Bigay à l'Observatoire de Lyon (F = 590 mm., F/1, 8) et celui de l'Observatoire de Haute-Provence, construit par A. Couder (F = 594 mm., F/2).

Sur films (ou plaques) Eastman 1 N hypersensibilisés, en arrêtant avec un filtre les radiations de longueurs d'onde inférieures à 7500 ou 8000 A., on obtient en 1^h ou 2^h de pose des images très détaillées du nuage stellaire dont l'existence a été mise en évidence par les mesures photoélectriques de Stebbins et Whitford et que Kaliniak, Krassovsky et Mikonov ont photographié au moyen d'un convertisseur d'images électronique ($\lambda \sim 9800$ A.). La photographie directe est aussi avantageuse que le dispositif électronique, car, si l'absorption interstellaire est plus grande à 8.000 A. qu'à 10.000 A., l'émission du ciel nocturne (bandes de OH) y est beaucoup moins intense. Ce nuage (*B*), pratiquement invisible en bleu, commence à se distinguer très faiblement en rouge ($\lambda \sim 6560$ A.).

Sur les clichés obtenus avec le télescope Schmidt de Couder, le nuage (*B*) est presque totalement résolu en étoiles dans ses régions périphériques, et partiellement dans ses parties les plus denses. En bordure du nuage, quelques étoiles indiscernables en bleu apparaissent extrêmement brillantes en infra-rouge.

On a tracé les isophotes relatives aux clichés obtenus avec le petit objectif. En infra-rouge ces dernières s'accordent assez bien avec ceux de Kaliniak, Krassovsky et Mikonov.

L'excès de couleur mesuré par Stebbins et Whitford sur l'amas globulaire NGC 6522 dans le grand nuage (*A*) du Sagittaire bien visible en bleu correspond à une absorption photographique totale de 2,6 magn. Si l'on admet provisoirement que le nuage *B* a une brillance propre comparable à celle du nuage *A*, l'absorption photographique totale sur le nuage *B* doit être de l'ordre de 5,5 magn. à $\lambda 4260$ A. et de 2,0 magn. pour $\lambda = 8100$ A.

D'après les astronomes russes la séparation apparente des deux nuages *A* et *B* résulterait seulement de la superposition d'une bande absorbante encore plus opaque et tous deux feraient partie d'un même ensemble (diamètre de l'ordre de 1600 pc) qui pourrait constituer ou contenir le noyau de la Voie Lactée. Baade estime en effet à 9000 pc la distance de l'amas globulaire NGC 6522.

Dr Baade, in connexion with Dufay's lecture, expressed the opinion that it should be impossible to find the nucleus in optical light but that it is necessary to use radio wave-lengths.

M D. Chalonge:

Mlle L. Divan a déterminé avec beaucoup de soin la loi d'absorption continue de la matière interstellaire dans trois directions différentes, vers ζ Per, vers HD 194279 (Cygnus) et vers HD 168607 (Sagittarius), pour tout le domaine de longueurs d'onde 3100–6000 A. Elle trouve que la loi d'absorption est exactement la même dans les trois cas.

Une étude actuellement en cours semble indiquer que la loi d'absorption en direction de θ_1 Orionis ne diffère pas des précédents (résultat en contradiction avec celui annoncé par Baade et Minkowski).

Dr Struve made some comments in connexion with this lecture. Dr Schalén reported on his investigation of stars in Cepheus where he had found a wave-length law deviating considerably from that of Cygnus.

Investigations carried out in the U.S.S.R. during the last two years

1. Investigations of diffuse gaseous nebulae by G. A. Shajn and V Gase (Simeis Observatory) are illustrated in detail in the *Report of the Simeis Observatory*.

1 (*a*). This *Report* contains also some hints as to the work carried out by S. B. Pikelner.

2. B. G. Fesenkov successfully used the new meniscus telescope (designed by D. D. Maksutov) and discovered many unexpected details in the structure of the star field and that of gaseous nebulae, as well as concerning the question of the connexion between the latter and the stars and dark dust clouds (*A.J Moscow*, **28**, 1951). There is a close connexion between the contours of the great gaseous nebula 'America' and the situation and distribution of faint stars. The turbulence structure of the nebula coincides with the identical structure of the star field. The majority of stars in the regions of 'America' and Orion have haloes, which are evidently caused by the absence of matter in the spherical zone around the stars (pushing away or pulling into of gaseous matter by the stars previously surrounded by it).

3. G. A. Gursadian investigated the problem of genesis of diffuse nebulae (*A.J. Moscow*, **29**, no. 2, 1952), criticized different mechanisms of formation of them and pointed out that the formation of gaseous diffuse nebulae goes in connexion and together with the formation of the stars.

4. A. J. Zebedinski and L. E. Gourevich tried to develop a theory regarding the formation of stars from diffuse matter from the point of view of gravitational condensation and investigated the dynamics of diffuse nebulae (*C.R. Acad. Sci. U.S.S.R.* **83**, no. 6, 1952; **84**, no. 2, 1952).

5. A. S. Sharov made a generalization of the well-known formula by P P Parenago used for computations of absorption. The modification by Sharov makes it possible to take into account the density gradient of absorbing matter simultaneously along two co-ordinates Z and R (*A.J Moscow*, **29**, no. 1, 1952).

6. G. S. Badalian published a list of colour indices of about sixty long-period cepheids (*Burakan Obs. Bull.* **8**, 1951).

7. V S. Safronov investigated the question of what kind of changes are undergone by the estimation of the density of matter after Prof. Oort, if we take as a basis contemporary values of galaxy size and of circular velocity of galactic rotation in the neighbourhood of the sun. He found an independent estimate of the density to be 7×10^{-24} gr./cm.^{3} (*A.J Moscow*, **29**, no. 2, 1952).

8. B. A. Vorontzov-Velyaminov has pointed to the role played by interstellar matter in the study of the distribution of hot giants (*A.J Moscow*, **28**, no. 5, 1951).

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9. S. F. Rodionov and his collaborators applied a new device: a wide-angle electrophotometer for observation in the region of about 1 micron.

10. A. Kaliniak, V. Krassovski and V. Nikonov found that the cloud of galactic nuclei is considerably larger in size compared with what had been supposed earlier. Its shape is nearly spherical.

11. V. A. Dombrovski showed that the polarization of a number of stars does not depend on the stellar distances and on the distribution of dark material, although he discovered a tendency of the polarization plane to be parallel to the galactic plane and suggested that polarization arises not in interstellar space, but that it is characteristic of the radiation itself in some stars, which perhaps are surrounded by ellipsoidal shells of free electrons (*C.R. Acad. Sci. U.S.S.R.* 1951).

It is quite right, as Prof. Struve states in the introduction to his Report, that the discovery of the polarization of stars opens an entire branch of research—that of interstellar matter—but, nevertheless, at the same time, in some cases the question of the possibility of existing sources of polarization in star radiation itself should not be forgotten or wholly ignored.

Prof. E. Schoenberg:

Prof. Schoenberg drew attention to two theoretical papers of Dr Gütter (Munich) concerning the constitution of interstellar matter. In his first paper Dr Gütter points out that it is impossible, on the basis of the wave-length law only—even if extended to the infra-red—to decide between metallic or dielectric particles. Furthermore, the measured albedos exclude metallic as well as dielectric particles. In his second paper Dr Gütter studies dielectric particles with a metallic core applying the Mie theory and finds that particles with a tiny metallic core behave just as if they were wholly of metal.

Following this communication Dr van der Hulst made some comments.

Prof. H. Lambrecht reported on current work at the Observatory of Jena, namely:

(1) A new computation of the interstellar radiation field with regard to deviations from isotropy in galactic latitude and to interstellar absorption particularly in the H I regions. Also deviations from the Planck radiation are paid attention to.

(2) Interpretation of the variation of the total absorptions of the interstellar H and K lines and Na lines N I and N II from cloud to cloud. The variations can be partly explained through density variations from one cloud to another.

(3) Investigations of the influence of the self-absorptions on the Balmer decrement in emission nebulae.

The detailed results will be published in a monograph on the interstellar medium which will appear at the beginning of next year.

Dr J. S. Hall:

The following programmes for measuring polarization are now in progress at the Naval Observatory. Three star fields near HD 231564 are being surveyed by Gossner. Five open clusters (NGC 7380, 457, 581, 663 and 1502) are being investigated by Hoag. About 500 stars of the 1332 stars in the SHW catalogue not yet observed are being investigated by Hall.

Magneto-hydrodynamics of filament formation, by DONALD H. MENZEL.

Filaments of gas are common features of the interstellar medium. Such objects as planetary nebulae, the network nebulae, the Pleiades nebulosity, etc., display a filamentous structure that has not been explained.

Gravitational forces will generally tend to produce globules—not filaments. The natural tendency of a gas to disperse will limit the lifetimes of filaments to some thousands of years, unless some force is acting to hold the material together. One possibility is the so-called 'pinch effect', the tendency of a gaseous cylinder carrying an electric

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current to contract radially The theory of this phenomenon has been studied at Harvard Observatory by P Bhatnagar, M. Krook and D. H. Menzel.

The magnetic fields probably have existed since the beginning of the expanding universe, if we adopt Lemaître's theory. The magnetic energies must be added to the gravitational energies, in the relativistic treatment. If we apply Kelvin's law of equi-partition to determine the general field in interstellar space, we get values roughly 100 times greater than that derived by Greenstein, Henyey, and others for equi-partition in the Galaxy alone.

This process would appear to provide a method for producing cylindrical condensations, whose further break up, by gravitational as well as magnetohydrodynamic forces, would produce multiple stars or clusters. A similar cylinder many orders of magnitude greater than the gaseous filaments of the Milky Way may lead to the formation of special galaxies, by a somewhat similar process. The above suggestion is speculative but perhaps worthy of further investigations.

Dr Zanstra:

Work in progress. At the Zürich meeting of the I.A.U. in 1947 Dr Menzel mentioned the discovery by Dr Baade of a large number of very curious condensations in the planetary nebula NGC 7293 in Aquarius.

Further information from Dr Baade induced H. Zanstra to formulate an approximate theory, as yet unpublished, in which it is shown that, in an ionized gas excited by high temperature radiation, two phases may sometimes occur: one dilute phase of high electron temperature, say 130.000°, and one condensed phase of low electron temperature, say 9000° The phases co-exist at equal gas pressure and the lower electron temperature in the condensed phase is a consequence of exciting collisions producing emission of forbidden lines, by which the free electrons lose their energy.

Les spectres de treize nébuleuses planétaires et de leurs noyaux par P. SWINGS et J. SWENSSON —Présenté par J. SWENSSON.

Notre rapport est basé sur une étude de spectrogrammes prises au foyer Cassegrain du télescope de 82 pouces à l'Observatoire McDonald aux Etats-Unis.

Quoique nous nous intéressions spécialement aux noyaux des nébuleuses planétaires, nous avons également examiné les spectres d'émission des nébuleuses et les avons comparés aux descriptions antérieures. En ce qui concerne les noyaux, on en trouve dont le spectre ressemble fort à celui des étoiles Wolf-Rayet non entourées de nébulosité—quoiqu'il y aie des différences: (1) largeur moins grande des raies des noyaux, (2) occasionnellement, présence simultanée de raies de N et C d'intensité analogue. D'autres noyaux présentent à la fois des raies d'absorption et d'émission. D'autres encore sont essentiellement des étoiles O à raies d'absorption avec vestiges d'émission (type Of). Enfin, il y a des noyaux à spectre parfaitement continu, dans lequel, avec les dispersions utilisées jusqu'ici, on ne trouve aucune trace de raie d'émission ou d'absorption.

I. *Noyaux WC typiques.*

Parmi les nouveaux noyaux WC typiques nous citons:

NGC 1501 (WC 6) et NGC 6905 (WC 6).

Dans le cas de NGC 1501 nous observons un excellent spectre nucléaire caractérisé par de larges raies C III 4069, C III 4650, et He II 4686. λ4650 possède une structure qui semble bien indiquer la présence de C IV 4658 dans l'extension de grande longeur d'onde. Aucun détail n'a été publié jusqu'ici.

Pour NGC 6905 notre spectre de noyau est excellent pour $\lambda > 3800$. Les bandes les plus intenses sont: une bande large λ3812–λ3835 due à O VI, une bande centrée vers λ4110 sans doute due à O V, C III 4650 plus C IV 4659, He II 4686 et C IV (λ5802 et λ5812).

Malheureusement, ces nébuleuses n'ont pas été observées au voisinage de He en vue de la détection de [N II].

II. *Deux probables noyaux WN*

Il semble bien que les noyaux de NGC 7009 et NGC 7662 soient des WN; ce seraient les premiers examples de noyaux de type WN.

NGC 7009. D'après Wright et Aller le noyau a un spectre continu, mais il nous semble que des émissions courtes en N III 4379 et N III 4641 sont nettement plus diffuses que les raies nébulaires et doivent être d'origine nucléaire.

NGC 7662. Spectre du noyau—consideré par Wright ainsi que Aller comme continu. Mais il nous semble bien qu'à la raie fine et longue N III 4641 due à la nébuleuse se superposa une raie large et courte due au noyau. Il y a une certaine évidence pour N III 4379 dans le spectre nucléaire; le doublet N V, λ4603 et λ4619, semble aussi présent.

III. *Noyaux WCN*

Les noyaux de NGC 6826, IC 351, et NGC 7026 combinent les raies des types C et N.

NGC 6826. L'intérêt spectroscopique principal de cette nébuleuse réside dans le noyau, que Beals a classé WN6. Nos clichés révèlent, outre un continuum intense, des émissions nucléaires bien marquées: N IV 4057, He II 4686, et C IV 5802+5812. Le doublet de C IV est bien séparé et apparaît très nettement sur le fond continu.

IC 351. Il semble bien que les raies de N III et de C IV soient présentes dans le noyau seulement.

NGC 7026. La raie nébulaire fine N III 4641 est superposée à une raie nucléaire plus large et plus courte. Il semble en être la même pour He II 4686. Entre λ4640 et λ4686 on observe une émission nucléaire diffuse qui doit être due à C III et, peut-être, à C IV. D'après $\frac{\text{H III 4641}}{\text{He II 4686}}$ nous donnerons le type W8, de préférence à W6 préconisé par Beals.

Dans les noyaux étudiés, les raies d'émission éventuelles présentent une énergie de beaucoup inférieure au spectre continu. En cela, les noyaux diffèrent fortement des étoiles Wolf-Rayet ordinaires, non entourées de nébulosités. Sauf très rares exceptions les raies des noyaux sont beaucoup moins larges que celles des étoiles WR ordinaires d'excitation comparable. D'ailleurs, de nombreux noyaux de nébuleuses montrent les raies des ions du carbone et de l'azote avec des intensités semblables, ce qui n'est le cas pour les étoiles W–R. Certes, C IV est présent dans les étoiles WN6 et même WN7; mais le carbone ne joue qu'un rôle mineur dans les étoiles WR à l'azote et l'azote est absent des étoiles WR à carbone. Au contraire, on connaît à présent au moins sept noyaux dans lesquels les raies de C et N sont d'intensité analogue. Il faut remarquer toutefois que *le carbon et l'azote ne se présentent simultanément avec des intensités analogues dans les noyaux que lorsque les émissions discrètes représentent beaucoup moins d'énergie que les continua.*