16. COMMISSION POUR LES OBSERVATIONS PHYSIQUES DES PLANÈTES, DES COMÈTES ET DES SATELLITES

PRÉSIDENT: Rev. T. E. R. PHILLIPS, Headley Rectory, Epsom, Surrey, England.

MEMBRES: MM. Andrèa, Antoniadi, Armellini, Baldet, Bobrovnikoff, L. Campbell, Delporte, Donitch, Dunham, Gastardi, Mlle Harwood, MM. Jarry-Desloges, Lampland, Luplau-Janssen, Lyot, Maggini, Nicholson, Peek, W. H. Pickering, Plakidis, Quénisset, Ross, E. C. Slipher, V. M. Slipher, Stroobant, Wildt, F. E. Wright, W. H. Wright.

The following work embodying researches coming within the scope of this commission has been published since the last meeting of the Union: *La Planète Mercure et la Rotation des Satellites*, by E. M. Antoniadi; Gauthier-Villars, Paris.

In addition to references to the work of other astronomers the author gives a summary of his own observations with the 0·83 m. refractor at Meudon and his conclusions.

The following Memoirs or papers not specifically referred to in the body of the Report have also been published since the last meeting of the Union:

Cometa Halley. Vol. XXV of *Resultados del Observatorio Nacional Argentino*. This is a monograph on the Comet at its 1910 return. By C. D. Perrine.

Les Comètes en 1930, 1931 *et* 1932. By F. Baldet. (*L'Astronomie* **46**, 497 et **48**, 175.)

I Fondamenti Psicologici dell' Indagine Visuale. By M. Maggini. (*Memorie della Soc. Astron. Italiana*, Vol. VIII, 2.)

Théorie Photométrique des Eclipses de Lune. By F. M. Link. (*Bulletin Astronomique*, **8** fasc. II.)

Relative Lunar Heights and Topography by means of the Motion Picture Negative. By R. R. McMath, R. M. Petrie and H. E. Sawyer. (*Pub. of the Observatory of Michigan*. Vol. VI, no. 8.)

Über den inneren Aufbau der grossen Planeten. (*Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen*, Fachgruppe I. Band I. Nr. 5.) This paper has also been included in the series *Veröffentlichungen der Universitäts-Sternwarte Göttingen*. By R. Wildt.

Interim Report of the B.A.A. Computing Section. (*B.A.A.J.* **45**, 274.) This contains predictions of the phenomena of Saturn's Satellites Rhea and Dione to the end of December 1934. Predictions of other Satellite Phenomena are to follow in a later number.

THE MAJOR PLANETS. SURFACE FEATURES

Venus. E. M. Antoniadi has analysed the drawings made by him with the 0·83 m. refractor at Meudon in 1928 and 1929. He has found that certain dusky markings recurred from time to time, and when seen remained apparently fixed for hours together and were often recorded in the same places on successive days.

His conclusion is that the planet is enveloped by an atmospheric shell in which large cloud masses are drifting in several layers. The dusky areas are most probably related to the character of the planet's underlying surface, but rarely, if ever, represent complete breaks in the cloudy strata. They are, however, believed to be at a lower level than the brighter regions, since they invariably indent the terminator—an appearance which it is believed is not entirely due to such causes as irradiation, bad seeing, etc.

As regards the problem of the planet's rotation, Antoniadi considers that the evidence suggests an axis nearly perpendicular to the plane of the orbit, and that in view of the apparent fixity of the markings observed in 1928 relatively to the terminator it may be said "the rotation period of Venus *seems* to be very long, and perhaps equal to the period of revolution" (*B.A.A.J.* **44**, 341 *et seq.*).

Several other papers on Venus dealing with observations of the surface features and the problem of the planet's rotation have been published by H. McEwen and others in *B.A.A.J.* **42**, **43**, and **44**.

Jupiter. T. E. R. Phillips has communicated to the British Astronomical Association the *27th Report of the Section for the Observation of Jupiter.* It contains a discussion of the observations made by members of the Section during the very remarkable apparition of 1928–9. The outstanding features of that apparition were the sequence of phenomena associated with the revival of activity in the planet's Southern hemisphere, including a series of dark spots at the S. edge of the S. Equatorial Belt, some of which showed the unprecedentedly long rotation period of over 9^h59^m! Valuable supplementary information was obtained from the remarkable series of photographs taken at the Lick and Flagstaff Observatories.

A. S. Williams has published papers on *Periodic or Secular changes of Velocity on Jupiter* in *M.N.R.A.S.* **93**, 409, **94**, 240 and 672. He finds evidences of a short oscillation in a period of about $2\frac{1}{2}$ years in the rotation of the north and south portions of the great equatorial current.

Saturn. After several years of quiescence the equatorial region became disturbed in the summer of 1933. A large bright oval spot was detected independently by W. Hay at Norbury, England, and A. Weber at Berlin on August 3, and this was followed by a second bright spot seen first at Flagstaff on August 29 and a few other features. Visual and photographic observations were secured at various observatories. Amongst the reports which have been published reference must be made to the full discussion by B. M. Peek of the observations available at the time of the original spot, and covering the period August 9 to September 10. The object showed a marked acceleration, and adopting the formula

$$T = T_0 + nP + \frac{n^2}{2}\Delta P$$

—where T is any observed time of central meridian passage reckoned from August $3^d22^h30^m$, P the instantaneous rotation period at that epoch, ΔP the change in the value of P per rotation (these quantities being measured in minutes of time)—he found that the following solution gave a very satisfactory accordance with the whole series:

$$P = 614^m{\cdot}947, \quad \Delta P = -0^m{\cdot}022, \quad T_0 = +2^m{\cdot}4$$

(*B.A.A.J.* **44**, 220 *et seq.*).

In no. 23 of *Contributi della R. Specola di Brera, Milano,* there is a discussion of micrometer measures of the original spot by P. Vocca between August 15 and September 4. A rotation period of $10^h13^m48^s \pm 36^s$ is derived (*Mem. della Soc. Astron. Italiana*, **7**, 3).

A discussion of micrometer measures of the same spot made at Stonyhurst is published by the Rev. J. P. Rowland, S.J. The period derived by him for the interval August 23 to 29 is about $10^h14^m{\cdot}14$ and this is compared with other published observations. The change in rate is very marked. The few observations of the

https://doi.org/10.1017/S0251107X00017193 Published online by Cambridge University Press

Flagstaff spot discussed in the paper give a rotation period of $10^h 14^m \cdot 07$ (*M.N.R.A.S.* **94**, 86).

An exhaustive analysis has been made by P. Stroobant of all the available data relating to the problem of the eccentricity of Saturn's Rings (*L'Astronomie*, **48**, 57, 121). The numerous measurements considered have been found to give in many cases apparently discordant results, and the main conclusions derived from the discussion are the following:

(1) The micrometer measures made under the best conditions by observers using powerful instruments show that the *mean* eccentricity of the various edges of the rings is extremely slight.

(2) The eccentricity does not permit a short period variation, but its changes are not inconsistent with the hypothesis of the rotation of the line of apsides of the orbits of the constituent particles of the ring under the influence of the perturbative force of the planet's equatorial protuberance, when the peri-Saturns of those particles find themselves together in the same direction relatively to the centre of Saturn.

(3) The study of the variation of the eccentricity can only be advanced if it is based on sufficiently continuous micrometer measurements made with the aid of instruments of great focal length at the epoch of the planet's opposition and repeated after an interval of at least four to five months.

Attention is drawn to the Presidential Address to the Astronomical Society of S. Africa (Session 1933–4) by D. G. McIntyre on the Translucency of Saturn's Rings. After a discussion of the available observations he concludes that all three rings are in some degree translucent. He also discusses the evidence for an outer crape ring reported at a number of observatories in 1907–8.

Pluto. A series of photographic magnitude-observations of Pluto is being made with the 42-in. reflector at Flagstaff to determine whether or not there is any appreciable variation in the planet's light. At present this appears to be the only method of gaining information as to its axial rotation. The observations so far indicate that any variation in brightness is within two or three tenths of a magnitude. The photographic magnitude is 15·5.

A photographic study of the magnitude and colour index of Pluto was made in 1933 by W. Baade with the aid of the reflectors at Mount Wilson. To avoid changes of comparison stars determinations were made as follows when the planet was nearly stationary:

(1) 1933 March 19–20 (8 plates with 40 inches of 60-in. refl.).

(2) 1933 Oct. 14–Nov. 16 (5 plates with 85 inches of 100-in. refl.).

The photographic magnitudes for the two epochs are $15{\cdot}56 \pm 0{\cdot}02$ and $15{\cdot}59 \pm 0{\cdot}03$. The adopted value (15·58) reduced to mean opposition is $15{\cdot}41 \pm 0{\cdot}02$. The mean colour index derived by the exposure-ratio method is $+0{\cdot}67 \pm 0{\cdot}02$ corresponding to spectral type G4 on the international scale. The photovisual magnitudes for the time interval discussed is 14·91 in good agreement with the visual photometric measurements by K. Graff which gave 14·88.

A comparison with Neptune's satellite Triton supports the conclusion of Bower (*L.O.B.* 444 and 453) who suggests that the two bodies are probably similar in size (*P.A.S.P.* **46**, 229).

Attention is drawn to the following papers: "Visual Measures of the Colour of the Planets and of Eros," by K. Graff (*Mitt. Wiener Sternwarte*, **1**, 25) and "Variability of the Outer Planets and Correlated Phenomena," by W. Becker (*Preuss. Akad. Wiss. Berlin*, **28**, 839, 1933).

Planetary Atmospheres. Spectroscopic Observations. The period since the last meeting of the Union has been marked by discoveries of the highest importance. It was noted in the last report of the Commission that R. Wildt had concluded that certain bands in the red and infra-red parts of the spectrum of Jupiter were probably due to the presence of ammonia in the planet's atmosphere. He subsequently showed that other bands agree with those of methane. These clues have since been followed up at Mt Wilson by Adams, Dunham, and Wildt, at Flagstaff by V. M. Slipher and Adel, and at the Perkins Observatory, Ohio, by Bobrovnikoff, and the identification of both substances has been completely established.

From a study of the bands of ammonia in the spectrum of Jupiter Dunham has estimated that the amount of the gas above the planet's reflecting surface is equivalent to a layer 5–10 metres thick under standard conditions and since radiometric observations indicate that the temperature at the surface is at least 25° C. below the freezing point of ammonia he concludes that the clouds of Jupiter may be composed in part of ammonia crystals. The bands of ammonia are also found in the spectrum of Saturn, but are there less intense as is to be expected in view of the lower temperature at the surface of that planet.

Bobrovnikoff has examined the spectra of the N. Equatorial Belt, Equatorial Zone, and N. Polar Regions of Jupiter, and has found that it is only in minor details that the spectrum of the belt differs from that of the Equatorial Zone and the Polar Regions. Lines of ammonia are present throughout the planet's disc, and he concludes that this gas does not play any important part in the formation of the equatorial belts which he believes to be at a very much lower level in the Jovian atmosphere (*P.A.S.P.* **45**, 171).

In 1934 Adel and V. M. Slipher published the results of an investigation which showed almost all the bands in the spectra of the outer planets (Pluto excepted), including the very prominent ν_3 series fundamental at $3{\cdot}3\,\mu$ and extending in the case of Neptune to the ninth harmonic together with associated series, to be due to absorption by methane. By making use of a 45 m. path and a pressure of 40 atmospheres they were able to reproduce bands intermediate in intensity between those in the spectra of Jupiter and Saturn. On the other hand the bands of the hydrocarbons ethane, ethylene, and acetylene have been looked for in vain—so that at any rate in the case of the outer planets the spectrum practically becomes entirely that of methane. This is in accord with the fact that the vapour pressure of methane at the very low temperatures which prevail in the atmospheres of the outer planets is very much greater than those of the other hydrocarbons which might be supposed to exist there. Dunham has remarked (*P.A.S.P.* **46**, 232): "As these planets cooled, carbon, nitrogen, and oxygen must have combined with part of the hydrogen. Of the hydrogen compounds of carbon, only methane, the most volatile, would be expected to show in the atmospheres. Ammonia is more easily condensed, so that while it is abundant on Jupiter it is scarcely detectable on the outer planets. All free oxygen must have combined with hydrogen, and the resulting ice must have fallen below the clouds. The spectra of the atmospheres of the major planets are, in fact, almost exactly what might have been anticipated from our theories of cosmogony and our knowledge of physical chemistry."

In 1932 July when Mercury was near greatest elongation a series of spectrograms of the planet was secured by Adams and Dunham with the aid of the 100-in. reflector at Mt Wilson. The part of the spectrum covered was from $\lambda 7500$ to $\lambda 8900$—a region in which many strong bands appear in the spectra of the Major Planets including the three carbon-dioxide bands in the spectrum of Venus. The linear scale of the spectrograms was about 16·3 A per millimetre, but no asymmetry of the telluric oxygen or water-vapour lines due to radial motion of these gases in the planet's atmosphere could be detected (*P.A.S.P.* **44**, 380). In further work on the spectrum of Venus, Adams and Dunham have found no evidence of the bands of oxygen or water-vapour, but have confirmed the suspected identification of three well-defined bands in the infra-red with those of carbon-dioxide (*P.A.S.P.* **45**, 202). Adel and Slipher, using a path of 45 m. and a pressure of 47 atmospheres, have concluded that the amount of this gas above the visible surface of Venus is equivalent to a layer 2 miles thick at standard pressure and temperature.

Adams and Dunham have searched but without success for definite evidence of oxygen in the atmosphere of Mars. Spectrograms taken when the planet was approaching and receding from the earth about the time of the 1933 opposition, so as to utilize the Doppler displacement for the purpose of distinguishing the planetary and telluric lines, failed to show any asymmetry of the oxygen lines whatever. They have concluded that if Martian oxygen exists it must be less than 1 per cent. of that present in the earth's atmosphere.

The following papers dealing with the question of the existence of ozone in planetary atmospheres have been published since the last meeting: D. J. Eropkin, *Die Naturwissenschaften*, **21**, 221, 1933 and R. Wildt, "Ozon und Sauerstoff in den Planetenatmosphären," *Gött. Gesell. der Wissen. Nachrichten*, Fach II, N.F. 1, 1.

H. N. Russell has suggested in his retiring Presidential address on 1934 Dec. 3 to the American Association for the Advancement of Science that most of the oxygen in the atmosphere of Mars has been used up in converting ferrous iron in the surface materials to the ferric state, and that the reddish colour of the planet may be due to this cause. This is in accord with a suggestion by Wildt, in the paper mentioned above, that in the thin atmosphere of Mars the layer of ozone caused by ultra-violet light would be near the surface, resulting in an acceleration of the process of oxidation. It is noteworthy that on the moon, which has been unable to retain an atmosphere, the rocks are grey or brown.

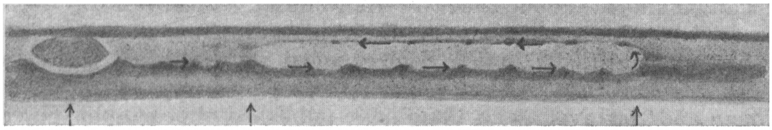
Telescopic Observations. E. M. Antoniadi has discussed his observations of Mercury made at the 0·83 refractor at Meudon during the years 1924 and 1929, and finding, as Schiaparelli had done, that some of the markings are apt to be temporarily obscured has inferred that this arises from clouds of some kind in a Mercurian atmosphere. Treating his observations quantitatively and adopting a scale of 0 (never obscured) to 100 (permanently obscured) he has found the region most affected to be *Solitudo Criophori* (a portion of Schiaparelli's figure 5) with a mean value of 45, while the region *Solitudo Hermae Trismegisti* received the value 5 only. It is suggested that the obscurations may be due to dust particles formed by pulverization of the planet's surface and raised by wind (*B.A.A.J.* **45**, 236).

Reference was made in the last Report of the Commission (p. 90) to the occurrence of what appeared to be a circulating current in the S. Tropical region of Jupiter. This was still in evidence at the close of the 1934 apparition. It has never, however, been possible to follow the features involved through a complete circulation. Becoming visible as crests or humps at the S. edge of the S. Equatorial Belt not far from the *following* shoulder of the Red Spot Hollow they have drifted in the retrograde direction and at first at an accelerating rate, past the *following* end of the S. Tropical Disturbance and along the edge of the belt as far as the *preceding* end of the Disturbance. This has seemingly presented a barrier to their progress and forced them southwards to the other side of the zone where they have travelled back with reversed motion as spots or short streaks on a narrow line close to the

S. Temperate Belt. But on again reaching the longitude of the *following* end of the Disturbance they have been lost either by coalescence with some almost stationary shadings on the zone or, perhaps, by passing beneath them. The general nature of the drift is illustrated by the following diagram:

S. Temp. Belt

S. Equat. Belt



S. Trop. Zone

Red Spot   f end Dist.   p end Dist.

THE MINOR PLANETS

The following report and recommendations have been received from L. Campbell and Miss M. Harwood:

Investigations of the light of Vesta (4) have been made visually by Kanamori of Kwasan Observatory, Kyoto (*Kwasan Bulletin*, 248), photographically by W. K. Green at Amherst (A.A.S. meeting Dec. 1934), and photoelectrically by W. A. Calder at Harvard. Dr Green plans to study the light variations of twenty asteroids; his plates are measured with a thermo-electric photometer. Uranus, Neptune, and Ceres (1) are also being studied by Dr Calder with a photoelectric photometer on the 61-inch reflector of the Oak Ridge Station of the Harvard Observatory. Metis (9) was observed with the polarizing photometer by Howells and Cuffey at Harvard in October 1934; no variation was detected.

We recommend: (1) further studies of the magnitudes, colour indices, and phase coefficients of the asteroids by means of simultaneous photometric and photographic observations extending over as great a portion of the orbit of each asteroid as possible.

(2) Studies of the spectra of as many asteroids as possible in different parts of their orbits.

(3) The variability in the light of asteroids and the fainter planets should be studied with photoelectric photometers as well as with direct visual photometers and photographically.

(4) The bibliography of Variability in the Light of Asteroids should be brought up to date and if possible published.

Attention is called to the fact that Eros will again be near the Earth and favourably situated for observation in the northern hemisphere from the autumn of 1937 to the spring of 1938. It will appear brightest about January 15. For this date the predicted visual magnitude allowing for the effect of phase is 8·7.

Results of Work on the Light of Asteroids, 1932–5.

The observations of the light of Eros from the photographs made at Nantucket during the opposition of 1930–1 are still in process of reduction and are yet to be published. Since the last meeting of the I.A.U., direct results have been published by Oosterhoff of Leiden, Taffara of Catania, Gadomski and Rybka of Warszawa, Guerrieri and Viaro of Capodimonte, Sotome of Tokyo, Ellsworth of Lyon, Balanowsky, Tikhoff, and Faas of Pulkovo and Beyer of Hamburg. Related papers and discussions of the results obtained in the opposition of 1930–1, which should be noted particularly, are: "Die Bestimmung der Winkelelemente der inneren

https://doi.org/10.1017/S0251107X00017193 Published online by Cambridge University Press

Bewegung von Eros," by W. Zessewitsch of the Tashkent Observatory (*A.N.* **246**, 441, 1932); "The Probable Mass of Eros," by K. Lündmark (*Lund Obs. Circular*, No. 7, 1932); "Determinations of the Effective Wave-lengths and Colour Indices of Eros and the Southern Primary Reference Stars," by H. Horrocks (*M.N.* **93**, 345, 1933); and two discussions of the photometric observations made by K. Graff at Vienna and Mallorca; in one paper by Graff himself (*Akad. Wiss. Wien*, **140**, *2a*, 499, 1931) he reports a variation in the colour of Eros; the other article by J. Rosenhagen is entitled "Einige Bemerkungen zur Helligkeit und zum Lichtwechsel des Planeten Eros" (*Akad. Wiss. Wien*, **141**, *2a*, 499, 1932).

Hartmann and Dartayet at La Plata have published photographic observations of Eros in 1933. The range of the variation was $1^{m}\cdot0$ in July, and $1^{m}\cdot4$ in August (*A.N.* **251**, 33, 1934). Variations have been reported in the light of Brucia (323) (*A.N.* **253**, 271, 1934) and of 1931 PH (*B.A.N.* **7**, No. 244, 65, 1933).

In view of the great demand for knowledge of the constitution of absorbing media, we should emphasize the importance of work on the spectra, colour indices, albedo, and light variations of the asteroids. Recent papers which pave the way and show the necessity for further investigations are: "The Magnitudes and Colour Indices of Thirty-six Asteroids," by Albert W. Recht at the Yerkes Observatory (*A.J.* **44**, 25, 1934), "Bestimmung der photographischen Helligkeit kleiner Planeten," by S. J. Beljawsky (*Poulkovo Obs. Circular*, No. 10, 1934) and "Über das System der Sterngrössen der Kleinen Planeten und ihrer Farbenindizes" by A. M. Deutsch of Pulkovo (*A.N.* **256**, 189). Recht finds a tendency for the light of asteroids to be bluer than sunlight. This agrees with Bobrovnikoff's work on Ceres and Vesta in 1929 (*L.O.B.* 407). In the cases of Psyche (16) and Urania (30) as well as that of Eros (433) there seems to be an actual variation in the colour. Of the thirty-nine asteroids measured photographically by Beljawsky, Nysa (44) is the only one which is also on Recht's list.

B. Lyot has been engaged in the study of the polarization of the light of Vesta and Ceres as well as of some of the smaller asteroids (*C.R.* **199**, 774).

The Royal Observatory at Uccle now possesses a very fine instrumental equipment, and a large amount of work both visual and photographic on the Minor Planets is being carried out by E. Delporte and other members of the staff.

SATELLITES

The Moon. An account by F. E. Wright of the work of the Special Committee of the Carnegie Institution of Washington for the study of the surface features of the Moon is published in the *Scientific Monthly* for 1935 February (**40**, 101–15). In mapping the Moon photographs taken with the 100-in. reflector at Mt Wilson are projected on to globes coated with photographic emulsion at the Research Laboratory of the Eastman Kodak Company. In the study of the physical nature of the surface the following four methods are used: (1) a visual method employing a special polarization eyepiece for the measurement of the amount of plane polarization in the rays from different points on the surface and at different phases; (2) a photoelectric-cell method for the measurement both of the amount of plane polarization and of the relative spectral intensities of the rays; (3) a thermo-element method for the same purpose; and (4) a polarization spectrograph. For (1) the field of the eyepiece is a divided photometric field in which two factors—equality of illumination and exact alignment of Savart's fringes—are the two criteria used in making a measurement. The results show that the mountains and lighter areas reflect more light and contain approximately half as much plane polarized light as that from the maria and other dark areas. In the cases of one or two of the maria a maximum value of 16 per cent. is derived. As previously found by Lyot the evidence is that the lunar surface has the nature of volcanic ash and pumice—a conclusion supported by the rate of cooling during an eclipse when the temperature falls, according to Pettit and Nicholson, from $+120°$ C. to below $-100°$ C. in the course of an hour. The polarization is at a maximum at the phase angles 100–110° and 250–260°, zero at $\pm 22°$ to 23° at 0° (full moon) and 180° (new moon). Near 0° the plane of vibration is in the plane of incidence and is negative. Work under divisions (2), (3), and (4) is in progress, and it is expected that it will be completed within the next two or three years.

A photographic investigation of the relative brightness of the surface of the eclipsed and full moon was made by R. L. Waterfield at Headley, England, on the occasion of the lunar eclipse of 1932 Sept. 14. The results in violet light are indefinite owing to the infra-red transmission of the violet filter. It can, however, be said that in an unknown mixture of violet and infra-red light the difference corresponds to at least 10 stellar magnitudes, or a light ratio of 10,000. In pure violet light the ratio must be larger. In infra-red light the following differences were deduced:

At effective wave-length $\lambda 8500$ 7·4 stellar magnitudes.
At effective wave-length $\lambda 8000$ 7·9 stellar magnitudes.

(*B.A.A.J.* **43**, 214 *et seq.*)

The Eighth Satellite of Jupiter. This was observed with the 42-in. reflector at Flagstaff during the 1934 opposition. Accurate positions were measured on 17 dates from March 10 to May 18.

G. Armellini suggests that systematic and precise observations should be made of positions of the fifth Satellite, and the polar flattening of the planet.

B. Lyot is planning to extend his polariscopic observations to the four great Satellites in the near future.

COMETS

General. On the recommendation of this commission, the writer of this note has published an article "On the Organization of Physical Observations of Comets" (*P.A.* **42**, 1, 1934). This article has been sent to the members of the Commission.

Although there were no bright comets during the period under review, a considerable number of articles of observational and theoretical character have been published. Especially active has been the comet section of the Russian Astronomical Institute. Practically all numbers of the Russian Astronomical Journal contain one or more articles on comets by the members of the Institute.

Spectrum. The occurrence of a continuous spectrum of the nucleus with the maximum intensity in the violet when the comet is far from the sun (farther than 0·7 A.U. on the average) was established by the author prior to 1932. This has recently been confirmed by a detailed investigation of the spectrum of Comet 1911 V (Brooks) by S. K. Vsessviatsky (*Russian A.J.* **10**, 164, 1933; also in less detail *Z. f. Ast.* **6**, 305, 1933). An indirect confirmation of progressive changes in the character of the continuous spectrum was made by B. Kukarkin (*Publ. Tashkent Obs.* **4**, pt 2, 1933) in his study of Comet 1930 II (Wilk). The colour index of this comet was found to vary with heliocentric distance. At $r=0{\cdot}51$ it was $-0{\cdot}5$, while at $r=1{\cdot}72$ it was $-1{\cdot}1$. The comet behaved exactly as one would expect on the basis of changes in its continuous spectrum.

An attempt to interpret the continuous spectrum of comets was made by W. Gleissberg (*Mitt. Univ. Stern. zu Breslau*, **3**, 69, 1932) and by W. M. Cohn (*Ap.J.* **76**, 277, 1932). Gleissberg has applied to comets the diffusion of light formulae derived by E. Schoenberg. He explains satisfactorily not only the origin of the "violet" continuous spectrum but also the changes in the distribution of intensity in the spectrum of the tail of Comet Morehouse depending on the distance from the nucleus. Cohn explains the origin of the violet spectrum (as well as other features of cometary spectra) as caused by streams of electrons emitted by the sun.

Neither of these theories can explain the multitude of observed facts on a quantitative basis. The existing material on cometary spectra is hardly amenable to a precise quantitative study. Perhaps the absence in recent years of bright comets well situated for observation accounts for a conspicuous lack of spectroscopic material obtained under controlled conditions.

The relative intensities of various bands in the cometary spectrum have been studied by several authors. The most thorough investigation has been done by Vsessviatsky (*loc. cit.*) on Comet 1911 V (Brooks).

The peculiarities in the structure of the CN band, $\lambda 3883$, in cometary spectra has been studied by N. Wurm (*Z. f. Ast.* **5**, 10, 1932). He concludes that the structure of the band can be explained by the low temperature in cometary heads.

The most important problems connected with the spectra of comets may be enumerated at present as follows:

(1) The origin of the so-called Raffety bands. These cometary bands have been shown by F. Baldet (*C.R.* **192**, 1531, 1931) to have nothing in common with the laboratory Raffety system.

(2) An exact photometric study of the continuous spectra of comets and of various bands.

(3) Observations of cometary spectra in the red and infra-red when strong *CN* bands must be present.

Mechanical Theory of Comets. Several investigations based on the Bessel-Bredichin theory of cometary forms appeared during the last three years.

The reality of extremely large repulsive forces, of the order of several thousand times the force of gravitation, was established by several investigators prior to 1932. A confirmation of these results comes from S. V. Orlov (*Russian A.J.* **9**, 163, 1932) who has found $1-\mu=2124$ in the tail of Comet Morehouse. E. H. Cherrington (*A.J.* **43**, 73, 1934) has found in the tail of the same comet $1-\mu=1288$ and 1367, as well as forces from 60 to 600. The occurrence of such large and not constant repulsive forces, acting apparently on the molecules of the same kind (CO^+) constitutes a very important problem in the dynamics of cometary tails.

S. V. Orlov on many occasions (the latest article, *Russian A.J.* **10**, 391, 1933) has called attention to the fact that according to his calculations the repulsive forces in comets are 22·3 times the force of gravitation, or its multiple. If this be so, it would mean an important clue to the physical processes in comets. It is difficult to accept these results. Unfortunately, the values of repulsive forces cannot be determined with high precision. The usual assumption that the particles of the tail are moving in the plane of the orbit of the nucleus is open to criticism. By varying the elements i and Ω (as was done by F. Gondolatsch, *Mitt. Astr. Rech. Inst.* **2**, No. 6, 1929) a variety of repulsive forces may be obtained which would satisfy observations equally well. It is in the nature of the problem that observations on particles in the tails of comets cannot be made with precision. Therefore the resulting values of repulsive forces should be considered as only approximate.

Vsessviatsky (*Russian A.J.* **9**, 166, 1932) has investigated the anomalous tails of some comets. He finds that these tails bear much resemblance to halos. The ejection of matter in the anomalous tails does not always occur in the direction toward the sun, as has been generally believed.

The expansion of halos in comets has been studied by the present writer (*P.A.S.P.* **44**, 296, 1932). It is found that velocities of expansion are rather small, in no cases exceeding 1 km./sec.

It seems to the author that much valuable material on the structure of comets has not been utilized yet. Many observatories possess photographs of comets which have never been published. Perhaps an international exchange of contact prints might be made practicable.

Brightness of Comets. This problem is still in a most unsatisfactory state. Estimates of brightness of comets are often made without an actual comparison with stars. Even when all due precautions are taken it is often impossible to compare observations made by different observers. Systematic errors are large and difficult to eliminate. The recent Comet 1932 V (Peltier-Whipple) was observed extensively in many places. By plotting observations against time practically nothing can be deduced from the combination of observations, except that the maximum of brightness occurred some time near August 25, 1932. Individual observations differ as much as 2^{m} for total brightness. More consistent results are obtained if observations of the same person extending over a long interval of time are considered.

The usual formula $H_0 = H - 5 \log \rho - 2{\cdot}5\, n \log r$ is not always satisfactory. A. Deutsch (*Poulk. Obs. Circ.* No. 4, 1932) has tried the formula

$$H_0 = H - 5 \log \rho - a \log r - b\, (\log r)^2$$

for comet 1930 II (Wilk). He has found that the latter formula represents observations better.

Probably the most remarkable change in brightness in the annals of cometary history occurred in the periodic comet 1925 II (Schwassmann-Wachmann). According to G. Van Biesbroek (*Ap. J.* **79**, 511, 1934) this comet increased in brightness (photographically) by five magnitudes within four days. The change is more remarkable when it is recalled that the perihelion distance of this comet is 5·3 astronomical units.

A valuable catalogue of absolute brightness of comets has been published by Vsessviatsky (*Russian A.J.* **10**, 327, 1933). It contains the total magnitudes reduced to $r = \rho = 1$ for 442 apparitions of almost as many comets. One of the results of this investigation is the corroboration of the fact that short-period comets gradually weaken.

Physical Theory of Comets. K. Wurm has discussed in two articles (*Z. f. Ast.* **8**, 281, 1934 and **9**, 62, 1934) the general mechanism of the physical processes in the comet. The first of these articles deals with the origin of cometary spectra, which are explained by the fluorescence along the lines suggested before by Zanstra. Wurm considers the duration of life for various molecules subject to the radiation of the sun and finds that it will be inversely proportional to the square of heliocentric distance. The contraction of the cometary head with the approach to the sun is thus easily explained. The difference in the duration of life for various molecules results also in the difference in the spectrum of the head and the tail.

In the second article these ideas are applied to a more detailed study of the structure of comets. Expansion of cometary envelopes is explained by the surplus energy of photo-chemical reaction converted into kinetic energy. These considerations are applied to the interpretation of the Bessel-Bredichin theory of cometary forms.

N. T. BOBROVNIKOFF
Secretary of the Comet Section
Commission 16, *I.A.U.*

1934 *December* 13

Recommendations. F. Baldet wishes to draw the attention of the members of the Commission to the detailed question of the continuous spectrum of Comets. When a Comet is presented under favourable conditions there is an opportunity of attempting to determine the distribution of energy in its continuous spectrum. The employment of a slit-spectrograph of considerable dispersion seems necessary.

S. B. Nicholson suggests that valuable statistical work on asteroids could be done by measuring the lengths and inclinations of trails on plates without actually computing the orbits, especially for the faint ones.

THEODORE E. R. PHILLIPS
President of the Commission

Headley, near Epsom, England

P.S. The following notes on the observation of comets were received by the President after the meeting of the Commission.

L'Institut Astronomique d'Etat du nom de Sternberg de l'Université de Moscou appelle l'attention des Astronomes sur les détails suivants dans les observations visuelles et photographiques des comètes:

1. A l'estimation visuelle des dimensions de la tête de la comète il est nécessaire de mesurer à part le diamètre (à travers le noyau) la distance du sommet de l'enveloppe (ou des enveloppes, s'il y en a plusieurs) au centre du noyau, marquant l'heure de l'observation de $0^{m}\cdot1$ de près. Il est à désirer que les mesures soient répétées de $0^{h}\cdot5$ à $0^{h}\cdot5$ et si un changement indubitable se manifeste il est nécessaire d'effectuer une série de mesures (5 au moins) avec des intervalles de temps d'ordre de $0^{h}\cdot3$.

2. Pour étudier les mouvements des divers détails dans la région de la tête de la comète (rayons, effusions, enveloppes, formations nébuleuses) un réflecteur lumineux et de long foyer doit être considéré comme étant le meilleur instrument qui donne des clichés détaillés des poses d'ordre de 10^{m}–15^{m}. Pendant la nuit il est désirable d'obtenir au moins 5–6 clichés à courts intervalles de temps (quelques minutes).

3. Pour étudier les mouvements des rayons et des formations nébuleuses dans les queues des comètes, nous envisageons comme le meilleur instrument l'astrographe lumineux de distance focale de 0·3 mètre au moins (les résultats obtenus sont plus précieux plus la distance focale est grande). Aux poses d'ordre 30^{m}–40^{m} il est désirable d'obtenir durant la nuit 4–5 clichés au moins.

4. Dans le cas de l'apparition d'une grande comète il est indispensable de photographier simultanément des parties éloignées de la queue avec une chambre lumineuse et de court foyer; la durée de la pose devant être d'ordre de 1^{h}: un cliché dans le cours de la nuit est suffisant.

5. Pour être en état d'explorer les changements de l'éclat superficiel des divers détails de la queue et de la tête d'une comète il est désirable de mettre des marques photométriques sur toutes les plaques (une marque de photomètre à tubes dans un coin).

6. Il est indispensable de photographier les têtes des comètes claires à l'aide des spectrographes à fente lumineuse soit-ce à petite dispersion, fixant la fente (à travers le noyau) en deux directions: le long du rayon-vecteur du noyau et perpendiculairement à cette direction, afin qu'on puisse isoler sur le spectrogramme les radiations du noyau, des enveloppes et des parties initiales de la queue. Une grande échelle de l'image sur la fente de spectrographe est désirable dans ce cas.

7. L'étude spectroscopique des faibles comètes est de grande importance, ainsi que l'obtention des spectrogrammes des comètes à grandes distances du Soleil (chambre prismatique à prisme de petite dispersion).

8. Une chambre prismatique lumineuse (prisme à grande dispersion) doit être considerée comme étant un meilleur instrument pour l'étude des spectres des queues des comètes.

9. Pour les estimations photographiques des comètes il est indispensable de mesurer l'éclat de la tête aussi bien que celui du noyau (éclat intégral) en marquant le moment d'observation et, autant que possible, la hauteur de la comète au-dessus de l'horizon.

En publiant les observations il est nécessaire de donner des renseignements sur l'instrument d'observation (diamètre de l'objectif, longueur focale, l'oculaire, le type du photomètre ou le type de binocle, l'œil nu, etc.), et d'indiquer les étoiles de comparaison.

Notes sur les observations visuelles et photographiques des comètes

1. La comète de 1908 III (Morehouse) a signalé un mouvement brusque des enveloppes vers le noyau; pour étudier les phénomènes pareils il est indispensable de faire des mesures à courtes intervalles en marquant les moments de $0^{m}.1$ de près.

2–3. La détermination de l'accélération repoussante du Soleil d'après les mouvements parmi les étoiles des divers détails n'est possible qu'en présence de non moins de 4 clichés de la tête ou de la queue de la comète.

4. L'étude des parties éloignées de la queue permet d'obtenir avec plus de précision la valeur de l'accélération repoussante du Soleil.

5. L'examen du régime lumineux de la tête et de la queue de la comète et de leurs détails nous met en état d'élucider les procédés physiques dans les comètes.

6. Si l'on place une fente le long du rayon-vecteur on peut obtenir simultanément le spectre des enveloppes, du noyau et des parties initiales de la queue; la fente placée dans une direction perpendiculaire permet d'étudier les enveloppes au niveau du noyau où l'on peut déjà attendre un brusque changement du spectre (spectre de la tête $(CN)_2$ et C_2 et de la queue CO^+ et N_2^+ (I type)).

9. L'éclat observé de la comète dépend du type de l'instrument employé pour l'estimation, et de la hauteur de la comète au-dessus de l'horizon. Ce n'est qu'à l'aide des moments d'observation, des étoiles de comparaison et du type des instruments qu'on peut former une liste homogène de toutes les estimations d'éclat.

La section des comètes de l'Institut Astronomique d'Etat du nom de Sternberg de l'Université de Moscou éprouve une grande difficulté vu l'absence de données d'observations et principalement de clichés photographiques des comètes. Les clichés des comètes qu'on trouve dans des journaux scientifiques en titre d'illustration ne peuvent toujours être utilisés pour nos études.

La section des comètes de l'Institut Astronomique d'Etat du nom de Sternberg de l'Université de Moscou s'adresse à l'Union Astronomique Internationale avec la prière de bien vouloir organiser entre des établissements scientifiques une échange régulière des clichés photographiques des comètes, qui sont d'une urgente importance pour les investigateurs.

S. Orlov

https://doi.org/10.1017/S0251107X00017193 Published online by Cambridge University Press