13. COMMISSION DES ECLIPSES DU SOLEIL

PRÉSIDENT: M. MENZEL.

MEMBRES: MM. Abetti, Allen, Bonsdorff†, Mlle Bugoslavskaya, MM. Carroll, Fesenkov, Grönstrand†, Grotrian, Hunter, Kiepenheuer, Lindblad, Link, Lyot†, Mikhailov, Millman, Minnaert, Mitchell, Parijsky. Righini, Slouka, Smiley, J. Q. Stewart, Stratton, Thomas, Torroja Menendez, van Biesbroeck, von Klüber, Woolley.

Since the Zürich Meeting, two total solar eclipses have occurred, November 1, 1948, and September 12, 1950. These eclipses were relatively inaccessible and of fairly short duration. Consequently recent observations are scarce. However, considerable work has appeared on the theoretical side, and in the reduction and publication of data secured at earlier eclipses.

The President of the Commission has called the attention of the Director of the Nautical Almanac and of the British Nautical Almanac Offices to the fact that the issued predictions appeared only one or two years in advance of the actual eclipse, which interval was often insufficient for detailed planning of expeditions. He requested that eclipse tracks be published ten years in advance. In a letter of August 28, 1951, G. R. Clemence reports:

For total solar eclipses through 1960, the central line, width of path, and duration on central line have been published in *U.S. Naval Observatory Circulars*. It is intended to continue to issue this information at least eight years in advance.

The British Nautical Almanac Office has supplied the tabular positions of the Sun and Moon for all eclipses through 1960; but with the present staff of the American Nautical Almanac Office, it is not now possible to undertake similar advance calculations for annular or partial eclipses.

It is planned to advance the regular eclipse computations for the *American Ephemeris* as rapidly as practicable. The computations for 1954 have been completed; and those for 1955 are in progress.

SUMMARY OF PUBLISHED PAPERS (1948–51)

The Relativity Displacement has been measured by G. van Biesbroeck and by A. A. Mikhailov, both of whom report displacements in excess of the theoretical value. Mikhailov's measurements of thirty-six stars from two pairs of plates (*Publ. Exped. of* 1936) gave a value of the coefficient of deviation of the rays in the Sun's gravitational field of $2''{\cdot}73 \pm 0''{\cdot}31$, which exceeds the theoretical value by 56%. The 1947 eclipse took place against a dark lane in Taurus, and thus afforded only a small number of measurable stars, van Biesbroeck obtained a result of $2''{\cdot}01 \pm 0''{\cdot}27$ (*Astr. J* **55**, 49, 1950). He does not consider, however, that his result definitely establishes an excess over the theoretical value of $1''{\cdot}745$. Further observations for this important test of the Theory of Relativity are needed.

Geodetic and Time of Contact Determinations. Solar eclipses present a special opportunity for improving the knowledge of large distances on the surface of the Earth, particularly of the distances between continents where methods of ordinary triangulation obviously fail. Determination of the distance between two observers of an eclipse, from the time interval required for the shadow to sweep from one observer to the other and the speed of the shadow relative to the surface of the Earth, requires: (i) accurate study of the motions of the Moon and Earth during the time involved, and (ii) observation of the times of contact at both stations, to within a few hundredths of a second. Even with modern cinematographic recording techniques, classical methods of contact determination based on direct photography of the solar crescent do not give the required accuracy. B. Lindblad, in 1943, suggested an entirely different procedure, based on an objective photometry in selected (i.e. free of strong lines) regions of the flash spectrum. The use of spectra instead of direct photography eliminates uncertainties arising from atmospheric turbulence, and permits the use of instruments of much shorter focal length.

https://doi.org/10.1017/S0251107X00032351 Published online by Cambridge University Press

Application of Lindblad's method by Swedish astronomers at the eclipse of 1945 has resulted in an important publication on 'Spectrophotometric Determinations of Contact at Total Eclipses of the Sun' by H. Kristenson (*Stockholm Obs. Annals*, **17**, no. 1, 1951), which gives a detailed discussion of the instrumental, timing and reduction procedure. 'The spectrophotometric procedure of timing a total solar eclipse utilizes the fact that the intensity at the extreme solar limb falls off very rapidly. When the Moon during the progress of the eclipse covers or uncovers the extreme photospheric layers, the light allowed to reach a terrestrial observer will accordingly decrease or increase with great rapidity. The moments of the inner contacts are settled from a study of the rate of change of light at both contacts.'

Swedish astronomers attempted to apply the spectrophotometric method to improve the geodetic connection of the continents of Africa and South America ('The Swedish Solar Eclipse Expeditions to West Africa and Brazil in 1947', *Rikets Allmanna Kartverk*, Meddelande No. 11, Stockholm, 1951). They secured observations successfully in West Africa but unfortunately the weather in Brazil prevented the making of any observations during the eclipse. Finnish scientists secured direct cinematographic recordings from Brazil and the African Gold Coast for the same eclipse (*Proc. Finn. Acad. Sci. and Letters*, 1948, p. 99, Helsinki, 1950). The National Geographic Society sponsored a geodetic expedition for direct cinematography of the annular eclipse of May 1948 (*Nat. Geog. Mag.* **95**, 325, 1949). R. Platzeck, A. Maiztegui, and E. Gaviola (*Nature*, **163**, 63, 1949) have also discussed the determination of the instants of totality in solar eclipses.

Solar Limb Darkening. Direct determination of limb darkening becomes more unreliable and difficult the closer one approaches to the limb, because of scattering and turbulence in the Earth's atmosphere. The method of Julius, designed to avoid this difficulty, measures the total light emitted by the uncovered crescent, and from the rate of change of intensity, derives the relative emission per unit area along a solar radius. M. Cimino (*Acta Pont. Acad. Sci.* **10**, no. 6, 75, 1948) has extended and applied the method of Julius to the partial eclipse of July 1945. K. Osawa has made photo-electric observations of the eclipse of May 1948 (*Tokyo Astr. Obs. Reprints*, No. 39, 1949), he has 'obtained the brightness distribution on the solar disk and concluded that the distribution is similar to that extrapolated from Abbot's values as far as $r=0{\cdot}99$, but it suddenly drops toward the solar limb' (under preparation). R. A. Richardson and E. O. Hulbert (*Ap. J* **111**, 99, 1950) made photo-electric measures of the eclipse of May 1947. They found the radial variation of intensity near the edge of the disk to be approximately linear, decreasing from 0·48 to 0·36 at 99·0–99·9% of the radius, with a slight trace of a shelf at about 99·6%. P ten Bruggencate, H. Gollnow and F. W Jager (*Z. Ap.* **27**, 223, 1950), from observations in red light of limb darkening, find a connection between optical depth τ and temperature, which suggests a slight temperature inversion between $\tau=0{\cdot}1$ and 0·2.

The method of Julius is not well suited to determination of the abrupt decrease at the very limb, because of the strong influence of irregular lunar topography H Kristenson (op. cit.) has applied the spectrophotometric method of Lindblad to study the energy distribution at the extreme limb of the Sun. This method permits measures at a single point on the lunar limb, and in a single wave-length, thus reducing atmospheric distortion. Kristenson used films made with an objective-prism spectrograph, with precisely timed exposures, and calibrated by means of a tungsten lamp. He measured the intensity decrease at six points of the solar limb, at λ4100 A. The plots of magnitude, m, *vs*, distance, h (time) give straight lines with small to moderate scatter, indicating that the relation m (h) is linear within the interval of h measured. Kristenson finds that the six different gradients, dm/dh, as determined by the method of least squares, do not differ more from their mean value than might be expected from the internal mean errors of the individual gradients. The final mean value of the photospheric gradient at 4100 A. at the extreme limb of the Sun is $dm/dh=5^{m}{\cdot}69\pm0^{m}{\cdot}11$ per sec. of arc. At the solar distance one sec. of arc corresponds to roughly 450 miles or 0·1% of the solar radius.

B. Lindblad has made spectrophotometric measurements of limb darkening around 4800 A. and (ibid. p. 51) finds a gradient of $dm/dh=4^{m}{\cdot}86$ per sec. of arc. His result is in

https://doi.org/10.1017/S0251107X00032351 Published online by Cambridge University Press

satisfactory agreement with the theoretical darkening computed by R. Wildt (*Ap. J* **105**, 36, 1947) on the assumption of H^- as the principal source of the continuous opacity. This important advance in the technique of measuring limb darkening should be extended to the measurement of a larger interval of intensity, to get a more complete picture of limb darkening. Kristenson points out that simultaneous observations with two or more instruments of different light-gathering power, or with a single instrument having variable and controllable light-gathering power, could greatly increase the range of the intensity measurements.

Y Fujita (*Publ. Astr. Soc. Japan,* **1**, 23, 1949) has used a slitless spectrograph to investigate the intensity variation of the continuous spectrum between 5200–5800 A., he discusses the variation of the absorption coefficient with optical depth. T. Tanaka and Z. Koana (*J Phys. Soc. Japan,* **5**, 95, 1950) have investigated the solar limb effect of certain spectral lines in a prominence observed at the eclipse of 1941.

Chromosphere. There are only a few new observations to report. O. Melnikov (*Pulkovo Bull.* **18**, no. 1, 1949) has made an important study of the intensity of the lines of the chromospheric spectrum from photographs taken during the total solar eclipses in 1941 and 1945. He finds changes in the relative intensity of various chromospheric lines and multiplets from 1941 to 1945, these changes are related to excitation potential of the multiplets, in the sense that the chromosphere was more highly excited during the eclipse of 1941 than during the eclipse of 1945. Melnikov notes that general solar activity was greater in 1941 than in 1945, and discusses the possible dependence of the chromospheric changes on solar activity.

Other Russian work includes a photometric study of the chromosphere spectrum in the region 3125–5180 A. by V Krat (*Publ. Exped. of* 1941, p. 238), and photometry of a prominence by D. Martynov (ibid. p. 208).

Considerable theoretical work has appeared since 1948, and most of it is concerned in one way or another with the temperature of the chromosphere. There is marked disagreement on this problem.

The High Temperature of the Chromosphere. In the interests of a complete picture of the present status of chromosphere research we may recall a couple of researches already reported in 1948. R. O. Redman (*M.N* **102**, 134 and 142, 1942), from a study of the half-widths of flash spectrum lines of different atomic weight, concluded that turbulence or mass motions could not exceed 1 km./sec. and that the line widths could be satisfactorily explained by assuming a random thermal velocity corresponding to a kinetic temperature of 30,000° K. R. Wildt (*Ap. J* **105**, 36, 1947), from study of the difference between the hydrogen and metal density gradients, was also forced to conclude that turbulence was negligible; he found that the H density gradient indicated a kinetic temperature of 30,000–35,000° K.

A recent study of profile half-widths as a function of atomic weight and of excitation potential in the absorption spectrum of the centre of the solar disk, by B. Bell (*Special Report,* No. 35, 200 pp., 1951, published under AMC Contract W 19–122ac–17), indicates negligible turbulence and a kinetic temperature in excess of the radiation and excitation temperature for the reversing layer. A temperature of 10,000° is indicated for the lower reversing layer, with an increase to around 20,000° in the upper reversing layer. This picture of a kinetic temperature increasing outward from the lower reversing layer is supported by evidence that the half-width of absorption lines increases to the limb, as shown by C. W Allen (*M.N* **109**, 343, 1949), K. Pierce and L. Goldberg (*Technical Report,* No. 2, ONR Project M 720–5, 1947), and G. Righini (unpublished). These results, while not directly pertaining to the chromosphere, tend to support the evidence of Redman and Wildt on the high kinetic temperature of the chromosphere. The appearance of He I and He II in the flash spectrum also indicates a temperature in excess of the photospheric value.

R. G. Giovanelli (*Aust. J Sci. Res.* A, **1**, 360, 1948) discusses the hydrogen chromosphere in the absence of thermodynamic equilibrium. He finds that the observed H density gradient corresponds to a kinetic temperature of 27,000° under conditions of hydrostatic equilibrium; the H atoms are almost completely ionized. Giovanelli has investigated also (loc. cit. pp. 275 and 289) the populations of the atomic levels of hydrogen for various temperatures and electron densities.

A series of papers by R. N. Thomas (*Ap. J* **108**, 130 and 142, 1948; **109**, 480, 1949; **110**, 12, 1949; **112**, 343, 1950) presents a theoretical investigation of a chromosphere with a kinetic temperature in excess of the temperature of the photospheric radiation field. In the first paper Thomas proposes that a mechanical source of energy maintains the high kinetic temperature of the chromosphere. He suggests that the chromospheric spicules, observed by W O. Roberts (*Ap. J* **101**, 136, 1945), comprise a system of superthermic jets which supply the energy needed by the chromosphere, as the mechanical energy of the jet gradually converts into random thermal energy as the jet moves through the atmosphere. He investigates the spicules from the hydrodynamical approach and finds such a jet system may put 2×10^{31} ergs/sec. into the chromosphere; as the energy per gram of chromospheric material supplied by a spicule increases with height, one may expect a rise of kinetic temperature with height.

In subsequent papers of the series Thomas considers departures from thermodynamic equilibrium. He derives the steady-state condition of a hydrogen chromosphere with a kinetic temperature of 35,000° and illuminated by a 6000° radiation field. The H is found to be 99% ionized; the minute neutral residue is strongly concentrated in the ground level. He extends the solution for the departure from the thermal equilibrium to include chromospheric absorption and emission in the radiation field. The variety of the solution that takes into account absorption in the chromospheric Balmer lines predicts a Balmer decrement in the flash spectrum in good agreement with observations.

In a second series of papers (*Ap. J* **111**, 165, 1950; **112**, 337, 1950), Thomas further investigates the Balmer decrement and the H gradient with height. Chromospheric density gradients have previously been determined by two methods: (1) the 'null method' (Menzel, *Lick Obs. Pub.* **17**, 1931) (Wildt, op. cit.), or comparison of the heights where various lines of the flash spectrum disappear, which avoids the numerical measurement of line intensities and minimizes the effects of self-absorption, (2) comparison of the intensity of a single line at different heights (Menzel and Cillié, *Harv. Obs. Circ.* 410, 1935), which if undistorted by self-absorption gives the variation with height of the number of atoms in various upper states of the Balmer series transitions. Thomas points out that at a kinetic temperature of the order of 35,000°, one should expect appreciable self-absorption in the Balmer flash spectrum. 'This realization that the hydrogen self-absorption cannot be legitimately neglected in many of the cases where it has been customary to do so provides a powerful tool for investigating the detailed atmospheric structure. . for a knowledge of the absorption as a function of height means a knowledge of the number of hydrogen atoms in the ground state of the Balmer series as a function of height.. The analysis rests only upon the observation that the kinetic temperature rises in the atmosphere and that self-absorption is therefore likely to be important. The *amount* of self-absorption comes from the observations themselves' and not from any theoretical considerations concerning the structure of the solar chromosphere. The theoretical prediction of the amount of self-absorption (see paper III of first series) agrees satisfactorily with the observed value, which agreement is not caused by any inclusion of the theory into the analysis for self-absorption.

Thomas applies his method to a numerical analysis of 1932 eclipse observations, and obtains the number of atoms along the line of sight in the lower Balmer level, $n=2$, at various heights. His values of atoms in this level exceed by roughly a factor of 100 those found earlier by Menzel and Cillié (op. cit.) who applied method (2) to earlier members of the Balmer series. From comparison of the number of Balmer atoms at different heights he obtains for the logarithmic emission gradient, $1{\cdot}8 \times 10^{-8}$ cm.$^{-1}$ atoms in state $n=2$. This result may be compared with that of Wildt, by method (1), of $0{\cdot}92 \times 10^{-8}$: and that of Menzel and Cillié, for $n>2$, of $1{\cdot}54 \times 10^{-8}$, or with correction for self-absorption, $1{\cdot}68 \times 10^{-8}$ cm.$^{-1}$

One has customarily identified the height gradient determined by methods (1) and (2) with the height gradient of hydrogen. However, as Thomas points out, this identification is valid only if excitation is constant with height, a condition that at present seems unlikely. Thomas emphasizes the importance of separating the apparent emission gradient into the contributions from (i) the gradient of H (electron density), and (ii) the gradient of the electron temperature, which he has done by introducing the assumption of hydrostatic equilibrium. His preliminary analysis of the anomalous behaviour of the flash Balmer decrement in terms of self-absorption predicts not only a positive kinetic temperature gradient ($dT/dh > 0$) but one whose numerical value is roughly that required to reach 10^6 deg. in the corona. Further, use of the gradients of other states, $n > 2$, determined by method (2) and corrected for self-absorption, as well as the gradient for $n = 2$, permits a simultaneous determination of (i) kinetic temperature, (ii) gradient dT_e/dh, and (iii) gradient $d \ln N_e^2/dh$ with roughly reasonable results. New observations of the Balmer decrement made for this purpose may be expected to give more precise results. This study of self-absorption effects constitutes a new and hitherto neglected set of observational data to advance our picture of the structure of the solar atmosphere.

The Low Temperature of the Chromosphere. The hypothesis of the high electron temperature of the chromosphere has been criticized by S. Miyamoto and I. Kawaguchi (*Publ. Astr. Soc. Japan*, **1**, no. 4, 114, 1950). They have computed the metallic ionization by electron collision as a function of electron temperature, T_e, and point out that the observations on metallic ionization and excitation appear to favour a T_e of the order of 6000° Miyamoto has further investigated the ultra-violet emission of the chromosphere. He concludes (*Publ. Astr. Soc. Japan*, **3**, no. 3, 102, 1951) from his calculations that if most of the H is ionized, as it should be at 35,000°, then the abundance ratio H/metals for the chromosphere is disturbingly smaller than the Russell mixture. He finds also (loc. cit. p. 113) that, assuming an abundance ratio H/He = 5, He I and He II should be as strong as the Balmer lines in the flash spectrum at a temperature of 35,000°; his analysis suggests $\sim$10,000° as most compatible with the observed intensities of the He lines.

H. Zanstra (*Astr. Inst. Univ. Amsterdam, Circ.* No. 1, 1950) has computed the intensity of the continuous spectrum for various wave-lengths to be expected in the chromosphere and in prominences, for different electron temperatures and densities, providing data for comparison with future observations. The observed intensity distribution in the Balmer continuum points to an electron temperature considerably below the kinetic temperature of about 30,000° derived from the widths of flash spectrum lines. Zanstra writes: 'if the main processes are ionization of hydrogen by various kinds of radiation, recombinations of protons and electrons, collisions of electrons with electrons and collisions of electrons with protons, it seems likely that the electron temperature should be the same as the kinetic temperature of protons or hydrogen atoms. This because the effective area of elastic collisions is very much greater than the effective area of capture of a proton for an electron. This presumable equality of electron temperature with kinetic temperature of atoms or ions emphasizes the importance of measurements of widths of emission lines both for the chromosphere and prominences.' Further, 'it would be very desirable to have the investigation of the continuous spectra leading to an electron temperature carried out at the same eclipse where the kinetic temperature from line widths is determined, if possible, at the same spot in the chromosphere, so as to make sure that the two temperatures are determined under the same circumstances' In this connection Thomas (*Ap. J* **112**, 337) points out that the conventional determination of T_e from the Balmer continuum is valid only if the Balmer continuum arises wholly from free-bound and free-free transitions in the chromosphere. He emphasizes the possible contribution of scattered 'photospheric' light to the Balmer continuum and notes that the scattered light, if present, should have an observable polarization.

R. v. d. R. Woolley and C. W Allen (*M.N* **110**, 358, 1950) have constructed a model of the quiet chromosphere at minimum solar disturbance which aims to fit as well as possible the data from observations of eclipses, of radio noise, and of the ionosphere.

They separate the chromosphere into two parts, the lower chromosphere at a temperature of 5040° up to 6000 km., and the upper chromosphere where the temperature ascends very rapidly. Woolley and Allen state that their choice of temperature was influenced mainly by ionospheric data on the solar ultra-violet emission. They 'were forced to adopt the low temperature to bring the Lyman continuum emission down to a level allowed by the ionosphere'

Radio Observations. According to a recent analysis by J. P Hagen (*Ap. J* **113**, 547, 1951) radio observations at the short wave-length end of the spectrum indicate T_e of about 10,000° for regions of the chromosphere where Redman's line widths indicate T_e of 30,000° The analysis assumes that present optically determined electron densities in the chromosphere are correct. J. H. Piddington (*Proc. Roy. Soc.* A, **203**, 417, 1950) has combined radio results with optical data in the form of intensities of spectrum lines at various heights to determine the electron density and temperature over the range of height 5000–15,000 km. The radio results he also finds difficult to reconcile with Redman's estimate of a kinetic temperature of 30,000° K. at 1500 km.

Eclipse observations at the short wave-length end of the radio spectrum are needed to give more precise information on the distribution of the source of cm. radiation over the solar disk, on whether the size of the radio source at 1 cm. exceeds the size of the optical disk. H. C. Minnett and N. R. Labrum report (*Aust. J Sci. Res.* A, **3**, 60, 1950) that their observations, made at wave-length 3·18 cm. during the solar eclipse of November 1948, are consistent with either of two simple brightness distributions on the Sun's disk. In the first of these, 74% of the energy is emitted uniformly by the Sun's visible disk and the remaining 26% by a bright ring around the circumference; in the second, the whole of the radiation comes from a uniform disk of diameter 1 1 times that of the visible Sun. At 1·25 cm. J. H. Piddington and H. C. Minnett report (*Aust. J Sci. Res.* A, **2**, 539, 1949) results consistent with 84% from a uniform disk and 16% from a narrow circumferential ring, by interferometric methods without eclipse. J. P Hagen, F. T. Haddock and G. Reber (*Sky and Tel.* March 1951) report observations from the December 1950 eclipse in the Aleutians, at 3, 10, and 65 cm. Observations at the shorter wave-lengths were hampered by rain, but the 10 cm. measures tend to favour a chromospheric temperature less than 30,000° Further observations during eclipse, especially at the shorter wave-lengths, should permit a radio determination of the chromospheric temperature and its gradient which would be entirely independent of optical data and theory.

Radio Observations and the General Magnetic Field of the Sun. If the Sun has a general magnetic-dipole field, the radio radiation should be circularly polarized, in opposite senses for the northern and the southern solar hemispheres. From the amount of the magnetic dipole moment one can predict the amount of polarization, or conversely from an observed polarization and the size of the source, one can deduce the magnetic field and dipole moment. Partial eclipses, where the Moon covers more or less one hemisphere of the Sun, are especially suitable for investigation of this effect, and several investigations have been made in Australia at the eclipse of November 1948. Eclipses are also useful in identification of discrete areas of the solar surface responsible for the enhanced radio emission.

Piddington and J. V Hindman (*Aust. J Sci.* A, **2**, 524, 1949) observed the intensity of solar radiation at 10 cm. during the 1948 eclipse, they measured also the average level of solar radiation for several days before and after the eclipse, for comparison with eclipse results. During the eclipse they found that the most intense radiation came from near the limb, while some radiation came from outside the visible disk. General polarization measurements were inconclusive, but definitely inconsistent with a general solar magnetic field as great as 50 gauss at the poles.

W N. Christiansen, D. E. Yabsley and B. Y Mills report (*Aust. J Sci. Res.* A, **2**, 506, 1949) 1948 eclipse observations of radio emission at 50 cm., measured from three well-separated localities. They interpret the abrupt changes of slope on the records of the received flux-density as the result of the covering and uncovering on the solar disk of small areas of great radio brightness. These areas were associated with some visible sunspots, with positions previously occupied by sunspots, and with one bright prominence. The bright areas had an average effective temperature of about $5 \times 10^{6\circ}$ K., and contributed about a fifth of the total energy received. The general distribution of the remaining four-fifths over the solar disk was consistent with a theoretical distribution involving limb-brightening, about 40% of the total radiation originating outside the visible limb of the Sun. The relative magnitudes of the two circularly polarized components of the solar radiation showed small differences as the bright areas were eclipsed. The eclipse of one hemisphere of the Sun produced no clear predominance of either polarized component, and thus afforded no evidence for a general solar magnetic field; the upper limit was 8 gauss for the surface magnetic field strength at the pole.

S. F. Smerd (*Aust. J. Sci. Res.* A, **3**, 1950) has used the equation of radiative transfer and the magneto-ionic theory to derive expressions for the degree of polarization of thermal 'solar noise' due to a general magnetic field of the Sun. He applies this theory to the net polarization of 50 cm. radiation corresponding to maximum phase of the November 1948 eclipse as seen from Melbourne, Victoria. Comparison with observation leads to an upper limit of 11 gauss for the surface field strength at the solar poles at the time of observation.

M. Laffineur, R. Michard, J. L. Steinberg and S. Zisler report (*C.R.* **228**, 1636, 1949) observations of percentage diminution of the received signal at maximum phase of the eclipse of April 1949, at 25, 55, and 195 cm.

The Temperature of the Corona. The various lines of optical evidence, summarized in the 1948 Report, agree in indicating kinetic and ionization temperatures of the order of $10^{6\circ}$ K. for the solar corona. This high temperature has been independently confirmed by numerous radio observations at metre wave-lengths (see, for example, *U.R.S.I. Spec. Rep.* No. 1, 47 pp., 1950).

The Coronal Spectrum. At the time of the eclipse of November 1948, M. Waldmeier (*Z. Ap.* **26**, 1, 1949) made observations of the coronal lines 5303 and 6374 A., with the Arosa coronograph. M. Notuki made a spectrophotometric observation of the relative intensity of the coronal lines at two different parts of the solar limb at the eclipse of February 1943; he points out a marked difference in the intensity of the emission lines 5303 and 6374 A. near a prominence (under preparation). At the same eclipse T. Tanaka and H. Oura (*J. Phys. Soc. Japan*, **5**, 101, 1950) have measured photographically the intensity distributions of the coronal lines 5303 and 6374 A. They find that the distributions differ between the lines and also between the east and west limbs. Over the range of $0{\cdot}2r$–$0{\cdot}4r$ from the solar limb, deviations from the distribution of the continuous spectrum are small, but become considerable for distances less than $0{\cdot}2r$. They found intensity maxima at $0{\cdot}11r$ for 5303 [Fe XIV] and $0{\cdot}17r$ for 6374 [Fe X]. Further study of the radial intensity distribution of various coronal lines, though observationally difficult, should contribute importantly to the knowledge of temperature gradients in the outer regions of the solar atmosphere. Such measures would be doubly valuable if it were possible to combine them with simultaneous measures of the radial variation in the profiles of the same coronal emission lines. The observational difficulties of such a programme, however, are admittedly very great, if not insuperable.

A. A. Mikhailov reports to the President a number of results on the corona from Russian studies of the eclipse of 1941 (*Publ. of Expeds. for Observ. of total Eclipse of Sept.* 1941, Acad. Sci. U.S.S.R. 1949). From visual photometric observations with filters, V. Sharonov (p. 99) deduced the colour temperature for the corona of 6100° K. By means of a four-camera coronograph with light filters transmitting red, green, blue and ultra-violet light respectively, G. A. Tikhov (ibid. p. 105) carried out a detailed calorimetric study of the corona and obtained a value of the colour temperature on the average close to the temperature of the Sun.

Photometry of the Corona. V. Nikonov (ibid. p. 43) used an antimony-bismuth thermocouple to measure the thermal radiation of the corona in the wave-length range of $0{\cdot}3 < \lambda < 5{\cdot}5\mu$, where he discovered an infra-red excess of about $0^{m}{\cdot}2$. For the integral brightness of the corona at $\lambda < 1{\cdot}3\mu$ he obtained a value of $0{\cdot}75 \times 10^{-6}$ of the solar

https://doi.org/10.1017/S0251107X00032351 Published online by Cambridge University Press

radiation. I. Chudovichev (ibid. p. 79) undertook electrophotometric observations with a potassium photocell and obtained for the integral brightness of the corona a value of $-11^m.02$ or $1{\cdot}08\times10^{-6}$ of the solar brightness. I. Ishchenko (ibid. p. 93) made photometric measurements of the solar corona using photographs taken from a standard coronograph. Reliable measures could be made along only 140° of the solar limb, because of clouds.

H. Alfvén reports (*Stockholm Obs. Ann.* **15**, no. 6, 3, 1949) photo-electric intensity measurements of the corona and the Sun during the total eclipse of July 1945. He used a Se barrier-layer type photo-element without a colour filter, and reduced the intensity of the solar disk radiation by successive surface reflections from black plates which were substituted in turn by mirrors as the eclipse progressed. Alfvén obtained a ratio of the intensity of the Sun to that of the corona $L_{sun}/L_{corona}=720{,}000$, without correction for scattered light. Curves show the change of intensity during the partial phases, and a detailed table gives the observations.

J. M. Ramberg reports (*Stockholm Obs. Ann.* **16**, no. 3, 1951) photovisual photometry of the corona at the eclipse of 1945. He has investigated the distribution of intensity in the corona and obtained isophotes whose radial distances are tabulated at 2°·5 intervals around the disk. The 1945 corona was of minimum or equatorial type. Ramberg's isophotal diagrams indicate that 'the polar flattening or ellipticity of the corona at first increases from the limb of the Sun outwards, and then again decreases at greater distances from the Sun' He finds also that the intensity of the minimal corona decreases more rapidly in the equatorial than in the polar region, while the most rapid decrease appears around $\pm 30°$, in the latitude of the spot zones.

Polarization of the Corona. The separation of the corona into two components, the F-corona and the K-corona, originally pointed out by Grotrian (*Z. Ap.* **8**, 124, 1933), is well known, and the 1948 Report has summarized the properties of the two components. According to independent theories by Allen (*M.N* **106**, 137, 1946) and van de Hulst (*Ap. J* **105**, 471, 1947) the F-corona arises primarily from diffraction by interplanetary particles between the Sun and Earth, rather than from reflection. Hence, the polarization of the corona arises entirely from the K, or electron scattering, component.

T. Tanaka, H. Oura, T. Mukakami and T. Mitunobu (*J Phys. Soc. Japan*, **5**, 106, 1950) at the total eclipse of 1943 examined the polarization of the continuous spectrum of the corona in the wave-length range 4200–6200 A. The polarization at a given height above the solar limb tends to decrease with increasing wave-length, but the authors suggest that this effect may be caused by the presence of light cloud and need not be regarded as a real difference. Tanaka (ibid. p. 110) has compared the intensity distributions observed in the region 4200–8600 A. at the eclipses of 1936 and 1943. The curves in different wave-lengths coincide, but systematic differences appear between the maximum and minimum types of corona. Tanaka discusses also the data on polarization given by Cohn (*Ap. J* **87**, 284, 1938) for the 1932 and 1934 eclipses, and concludes that any dependency of polarization on wave-length is spurious. The effect of sky-light on the polarization curves is discussed.

From two photographs, corresponding to wave-lengths of 5000–5600 A. and 6000–6400 A., G. Jarnefelt, H. A. Alikoski and P. Kustaanheimo (*Ann. Acad. Sci. Fennicae*, ser. A I, no. 48, 44 pp., 1949) have obtained relative intensities of parts of the solar corona during the total eclipse of July 1945. By comparing their equatorial intensities with those of Öhman (*Stockholm Obs. Ann.* **15**, no. 2, 58 pp., 1947) they are able to deduce absolute intensities and thus extend Öhman's results.

M. Vashakidze (*Publ. Exped. of* 1941, p. 186) investigated the polarization of the solar corona and found that the light from the corona shows a 40% polarization in visual and slightly more in photographic light. The direction of the plane of polarization is approximately radial in all parts of the corona.

K. Saito (*Tokyo Astron. Bull.* **2**, no. 8, 1948) at the eclipse of 1943 found that the polar polarization exceeded the equatorial one near the solar limb, became almost equal at 4′ and then was reversed at a greater distance for the wave-length 6670 A. Saito further

https://doi.org/10.1017/S0251107X00032351 Published online by Cambridge University Press

(*Ann. Tokyo Astr. Obs.* **3**, no. 1, 3, 1950) investigated the observed brightness and polarization of the solar corona on the hypothesis that the corona is composed of three parts: (i) the zodiacal light, (ii) the coronal streamers and (iii) the inner corona of symmetrical shape. He showed that the first term in Baumbach's formula for the brightness distribution in the corona corresponds to the zodiacal light and the sum of the other two terms to the true K-corona. He derives an expression for the electron density in the true corona, and compares the computations with observations of polarization. Analysing the discrepancies among observations of the outer corona, Saito finds evidence of a periodic variation in the intensity of the true corona, with an amplitude of $\pm 35\%$ about its mean value of $1 \cdot 24 \times 10^{-6}$; the total light of the corona varies between $1 \cdot 97 \times 10^{-6}$ and $1 \cdot 10 \times 10^{-6}$ of the Sun, with the minimum occurring about a year after spot minimum. Saito considers theoretically the polarization of the corona for the case of a non-spherical or oblate corona, and investigates also the polarization and electron densities in coronal streamers.

K. Takakubo (*Publ. Astr Soc. Japan*, **2**, 14, 1950) has recalculated the polarization of the corona with new information about the corona, and finds evidence that the electron density of the corona and the gradient of its distribution fluctuate strongly with time and position. He discusses the distribution of the interplanetary particles with respect to their sizes and distances.

Structure of the Corona. Mikhailov reports several Russian studies on this problem at the eclipse of 1941. Photographs obtained by V Fessenkov (op. cit. p. 11) near Alma-Ata, with various instruments ranging from 45 cm. to 6 m. in focal length, showed that during this eclipse the corona had a very complex structure. From photographs taken with an objective of short focal length and large aperture Fessenkov (op. cit. p. 183) determined the ellipticity of the corona and found that if the influence of the Earth's atmosphere is taken into account, this ellipticity remains constant up to a distance of 2° from the Sun and equals 0·8 for the eclipse of 1941. The so-called globular corona does not exist in reality but is merely an atmospheric effect.

E. J. Bugoslavskaya (*Bull. Solar Comm. U.S.S.R.* No. 5, 1950 and earlier publications) has investigated the structure of the corona from observations at several eclipses, and finds that the structural features of the corona and their physical characteristics are determined by the formations on the surface of the Sun. Among the features studied were rays over the faculae, rays in the polar regions, helmet-shaped streams over prominences, arcs over the prominences, and ejection from sunspots. Strong evidence is presented for the existence on the Sun of electromagnetic forces, for general and local magnetic fields which influence the individual formations of the corona.

Bugoslavskaya (*A.J U.S.S.R.* **23**, no. 4, 1946) has used a protuberance-spectrograph on a 7-inch refractor to investigate the chromosphere spicules during the period of low solar activity of 1943–45. Many of the spicules inclined from the normal to the solar surface; inclinations towards the equator were observed in all latitudes, inclinations from the equator only in the active zones. From photographs of the polar chromosphere during the eclipse of 1941 Bugoslavskaya, M. S. Seltzer and A. V Markov (*Publ. Exped.* p. 150) conclude that polar rays originate from the chromospheric spicules, the inclination of the latter relative to the solar radius varies with latitude in the same manner as the rays.

H. C. van de Hulst reports (*B.A.N* **11**, no. 410, 150, 1950) a photometric study of the polar rays from copies of a photograph taken by Barnard at the eclipse of 1900. From his determination of isophotes for the north polar region, van de Hulst finds that the surface brightness of the rays exceeds the brightness of the background by 20% at most. After eliminating the F-corona and converting the results to electron densities, N_e, he finds N_e to be five times larger in the rays than between them. The density decreases outward along the ray in a very similar way as between the rays. Van de Hulst considers that the polar rays cannot be explained as ejected streams because their densities decrease too rapidly outward. He suggests that they coincide with lines of force of the general magnetic field of the Sun. Thermal diffusion carries an initial disturbance along the lines of force in a few hours, thus forming a ray; diffusion perpendicular to the lines of force he shows to be negligible, even for a very small field. He calls attention to the form of the rays as a source of information about the character of the magnetic field.

Coronal Model. Van de Hulst has contributed a new discussion of the brightness, electron density and polarization of various parts of the corona (*B.A.N* **11**, no. 410, 135, 1950 and *Nature*, **163**, 24, 1949). Since these quantities have rather complex interrelations, he has prepared some tables giving mutually consistent values of the quantities. These tables he calls the 'model corona' and expresses the hope that future changes may be relatively small and easily made. The computation of the model starts from the brightness data collected by Baumbach, and new absolute values are computed exclusively from photo-electric measures of the total corona. The measures suggest that the brightness of the corona in maximum phase is 1·8 times the brightness in minimum phase. The F-corona van de Hulst eliminates on the basis of observations of the Fraunhofer lines therein. He discusses a method for computing the polarization and electron densities from observed brightness, and finds some discrepancies between observed and computed values of the polarization. He suggests that the discrepancies may come partly from an over-correction for sky brightness in the outer corona, and an overestimation of the brightness of the F-corona in the inner regions, especially in the polar regions. Van de Hulst considers the equatorial and polar densities individually and points out that the polar corona appears to be separated from the equatorial corona by a density minimum near 70°—a dependence on latitude unlike that of any other solar phenomenon. He gives (loc. cit. p. 150) a theoretical discussion of the equilibrium state of the entire corona, as well as that of the polar rays. He finds the observational data more consistent with the concept of an isothermal corona in static equilibrium than with the hypothesis that the corona is a collection of fast streams ejected by the sun.

Discussion of Future Eclipse Problems

Coming total eclipses

Date	Max. duration (min.)	Where visible
June 30, 1954	2·6	Quebec, Greenland, Scandinavia, Russia
June 20, 1955	7·1	Ceylon, Siam, Indo-China, Philippines
Oct. 12, 1958	3·5	Phoenix Is., Society Is., Tuamotu Archipelago, etc.; Pacific Ocean
Oct. 2, 1959	3·0	Rio de Oro, French West and Equatorial Africa, Ethiopia

H. O. Grönstrand (*Stockholm Obs. Ann.* **16**, no. 2, 1950) has computed details of the eclipse of June 1954 for Scandinavia.

Instrumentation

Instruments should be completely built, adjusted and tested in the laboratory before one proceeds to the eclipse site, to minimize the assembly work needed at the site. Building instruments on the site, though often done, should be avoided as far as possible.

Because of the short duration of the eclipse, the polar mounting can be relatively primitive as long as it is rigid and accurately controllable during the eclipse. The mounting should be capable of rapid adjustment, because clouds may break only a few minutes before totality. Probably not more than one instrument should be put in a single box. However, a single polar axis can be shared by three or four instruments, each in its own box, with the various boxes mounted on a single board. Then when one instrument is aligned the others will automatically be aligned at the same time. Telechron or other synchronous motor drives can now largely replace weight-driven clocks.

All recordings should be taken with standardizations. Control development technique even in the field as precisely as possible, so that standards can be repeated in the laboratory afterwards if necessary. At the eclipse one would do well to make additional standard plates which should be taken home undeveloped for comparison with others made at home. As far as possible seek absolute standards.

The importance of spectrophotometric calibration of all spectra cannot be overemphasized. All spectral plates should be calibrated with (i) an intensity scale for a given wave-length; (ii) a single intensity at various wave-lengths, for relative intensities; (iii) if possible for absolute photometry

The President has found jumping-film techniques preferable to Campbell's continuously moving plate, because in the latter method prominences are likely to interfere and produce doubling or blurring of the lines of the flash spectrum.

Recent improvements in polaroid filters and the extension of their range of sensitivity should make possible important advances in polarization studies. The use of colour filters in conjunction with polaroid should also yield valuable information. To minimize scattering one should preferably place filters and polaroid close to the focal plane rather than in front of the objective.

Centre-Limb Effects

1. Extension of Swedish spectrophotometric method to the determination of limb darkening at several wave-lengths, and over a wider interval of intensity.

2. If possible one might make, simultaneously with the Swedish-type objective-prism records, observations with a slit spectrograph, cinematographically recorded and precisely timed, with the slit following close to the edge of the Moon. Such observations should contribute information about the rate of disappearance of absorption lines at the extreme limb. They should also help to provide more precise definition of 'heights' in the chromosphere.

Chromosphere and Prominences

1. *Line Widths*. The most direct evidence for high kinetic temperatures in the chromosphere lies in the observed widths of the spectral lines. New observations are needed to confirm Redman's results. Also, do widths vary with the sunspot cycle and with the general level of chromospheric excitation and ionization?

(*a*) Choice of spectral region. Redman, working in the blue, found blends troublesome. The green-yellow-red spectral regions offer an advantage through possessing more lines free of blends and suitable for measurement. In selecting wave-length regions one should keep in mind the importance of obtaining lines from atoms of various weights. Rare earths occur mainly to the violet of 4500 A. Redman, however, found no difference between rare earths and relatively light elements of the iron group. Perhaps the limited resolution obtainable on eclipse spectra does not permit adequate resolution of the narrowest lines. One might do better to compare iron and titanium with silicon and carbon for instance. The region 4700–5500 A. contains a few lines of C I, which should probably appear in the chromosphere although Mitchell does not list them. The region 5600–6200 A. contains a good collection of Si and Fe lines; also Si II at 6300–6400 A., a strong He line at 5875 A.; Al at 6698 A.

(*b*) If possible one should measure the widths at several heights above the limb. Because a temperature gradient probably exists in the chromosphere, one should compare only line-widths measured at the same height. Redman has pointed out that distortion by self-absorption in the Balmer, He and H and K lines at low levels, and the absence of metallic lines at the higher levels, prevent a comparison between H and He on the one hand and the metals on the other, at the same level in the chromosphere. Thus in going beyond a first approximation one should probably not compare H and He at all

https://doi.org/10.1017/S0251107X00032351 Published online by Cambridge University Press

with metals; but rather determine the kinetic temperatures in the upper chromosphere from intercomparison of H, He, and Ca II; and in the lower chromosphere from comparisons between Fe, Si, C, etc.

(*c*) To link together the chromospheric and reversing-layer results, and to provide a check on instrumental profile corrections, observers of chromospheric line-widths might well employ their eclipse spectrograph to record also the solar absorption spectrum of the centre of the disk, either before or after the actual eclipse.

(*d*) The entire profile and not merely the half-width of the lines should eventually be measured. One should investigate whether lines in the low chromosphere show any damping wings, as one might suspect from Redman's fig. 2. One might profitably apply the Voigt profile method of correction for instrumental distortion (see H. van de Hulst and J. Reesinck, *Ap. J* **106**, 121, 1947) and analysis for damping (see B. Bell, op. cit.). From measures of damping and use of the theoretical relation between the amount of damping and density of perturbing atoms, one might then compute densities for comparison with absorption data. Such an analysis should contribute information on the density gradient in the solar atmosphere. Observation and analysis of the series lines of Mg I would be especially useful to give an estimate of the relative H I and electron density, from the relative importance of van der Waals and quadratic Stark broadening in their wings.

2. Measures of the relative intensities of the lines of the Balmer and Paschen series of H, and analysis for self-absorption; extension of the analysis to He.

3. Redman comments (op. cit.): 'The chromospheric spectrum at low levels appears to be rather more complicated than the normal Fraunhofer spectrum of the Sun's disk, so that the number of lines which can be measured and identified on a properly exposed photograph at present depends solely on the resolving power of the spectrograph.' One should make a thorough search for faint O- and B-type lines, and forbidden nova-type lines of ionization intermediate between the chromosphere and the corona, e.g. [N II], [O III], [Ne III, V], [Ca V, VII], [Fe III, V, VI, VII]. There is already some evidence of [O I] and [Fe II] in the solar absorption spectrum (Bowen, *Rev. Mod. Phys.* **20**, 109, 1948; Cabannes and Dufay, *C.R.* **226**, 1569 and 2032, 1948) and in the chromospheric spectrum (Cabannes and Dufay, *C.R.* **226**, 1569, Bowen and Menzel, *P.A.S.P* **40**, 332, 1928). A further search should be made for forbidden lines in the chromospheric spectrum, although many of them have transition probabilities too small to be at all likely of detection. Look also in the ultra-violet, 3070–3300 A. for lines of doubly ionized rare earths (see Swings, *Ap. J* **100**, 132, 1944).

4. The variation of excitation and ionization in the chromosphere with the sunspot cycle. Heights and intensities of lines should be determined from a single eclipse, and data from different eclipses should be kept separate.

5. Radio observations especially at wave-lengths less than 10 cm., to fix more precisely levels of origin and provide independent determination of the chromospheric temperature gradient and electron-density gradient.

6. Zanstra emphasizes the importance of the determination of the ratio of the Balmer continuum to the general continuum, for electron temperature. Attention should be given to the contribution of scattered 'photospheric' light to the Balmer continuum intensity. Thomas (loc. cit.) has pointed out that both the relative amount of scattered light and the percentage of polarization may be expected to increase with height in the chromosphere. He emphasizes the desirability of measuring the emission at several wave-lengths in the Balmer continuum as a function of chromospheric height, as well as investigating the polarization and its variation with height.

Zanstra suggests measuring the ratio of the Balmer continuous intensity to the intensity of the general continuous spectrum in prominences as well as in the chromosphere. Wurm (*Mitt. Bergedorf*, **21**, no. 206, 103, 1948) recently showed that this ratio should yield the proton concentration per cm.^{3}, if the electron temperature is known. Also Zanstra points out that 'the intensity of the general continuous spectrum per cm.^{2} yields the electron concentration times the thickness of the prominence. Dividing this by the above proton concentration per cm.^{3} which is about the same as the electron concentration, one determines the thickness of the prominence in centimetres.

7. Zanstra points out that Lyot has found the degree of polarization of the general continuous spectrum of prominences to be about the same as that of the lower corona, and accordingly concludes that the former is also due to the scattering of photospheric radiation by free electrons. One should attempt also to observe the degree of polarization in the general continuous spectrum of the chromosphere, to determine the importance of electron scattering in its formation.

8. *Polarization of Emission Lines* in prominences and chromosphere. Zanstra writes that 'one must be prepared for a possible destruction of polarization if, on account of the high electron temperature, the lines are excited by electron collisions rather than by photospheric radiation'. Thus observations of the degree of polarization in chromospheric and prominence spectral lines should give information on the relative importance of collisional and radiative excitation in these regions.

Zanstra (*M.N.* **110**, 491, 1950) has used the theory of Heisenberg as developed by Öhman to predict this polarization for various spectral lines when circumstances are most favourable. The theory, given for a prominence of small total optical depth, predicts for the emission a degree of polarization of 1·6% at the photosphere, and 7·5% at an altitude of 50,000 km., as compared with Lyot's observed values of 0·8% to 1·2% in general, for H_α. For the D_3 emission the theory gives 2·6% at the photosphere and 8·4% at 50,000 km., as compared with the observed 0·9 to 1·5%. Also the fact that the plane of vibration is not parallel to the solar limb, but shows deviations of between 0° and 30° for H_α and 0° to 40° for D_3, is not explained by the simple theory. Zanstra suggests that further measurements of the degree and plane of polarization for lines of various elements and ions would be an important aid to the improvement of the theory.

9. Öhman suggests that photographs of the corona be taken with a birefringent filter or similar device transmitting only about 1 A. at the H_α line. If the exposure time is long enough (about 2 min. on a sensitive emulsion for a *f*/10 instrument transmitting about 20% of the light of H_α), very faint prominences should show up on the photographs; also if dark prominences or lanes are present, these objects should be expected to stand out against the background formed by the inner corona. The presence of such dark structures in H_α is indicated by wide slit spectra secured recently with the Climax and Sacramento Peak coronographs. A similar study in the K-line would be of interest and here a somewhat wider transmission band could probably be used.

Corona

1. In order to study the structure, polarization, intensity, etc., of the true or K-corona, one must first eliminate the F-component. The method of Grotrian, which measures the depth of the Fraunhofer lines in the corona, and requires high dispersion and accurate photometry, is the only direct method for separating the components, and in the opinion of van de Hulst the most reliable. Further measures by this method are needed both at the poles and the equator of the corona, at various distances from the solar surface, and both inside and between the streamers. Measures should be made at various phases of the solar cycle. Van de Hulst has suggested that, as the F corona is probably the same at pole and equator, one might measure F at one or two points and the total at several points; then by assuming F constant one could get K at various points more quickly.

2. Large-scale, short-exposure photographs should be made near contact, to investigate the details of the structure of the inner corona, including also the spicules, and the relation between spicules and coronal rays suggested by Russian astronomers (Bugoslavskaya, etc.). There has been a tendency to use faster and faster cameras and longer exposures, which give information on the outer corona but leave the inner corona hopelessly over-exposed. Detailed study of the structure of the inner corona requires a slow camera with large scale and relatively short exposure. The very shortest exposures should give information about the chromosphere and spicule structure as well as that of

prominences. For plates with speeds approximately equal to the 'E-40', and a camera of focal ratio 120/1, exposures of the order of 1–2 sec. will show some detail in the inner corona.

3. Photometric measures of the colour of the corona as compared with the colour of the solar disk. The corona and the disk should be of the same colour if the corona results entirely from electron scattering; whereas dust should make the corona redder or bluer according to the size of the particles. Thus, as Blackwell has mentioned in conversation, study of the colour of the corona at various distances from the limb should give information about the proportions of electrons and dust in the corona at various distances, and information on the size of the dust particles.

4. Extension of study of the corona and chromosphere into the infra-red, by use of PbS cells and phosphors for recording.

Corona, Spectral Lines

1. Polarization of the coronal Fraunhofer spectrum. Öhman suggests that a spectrophotometric Grotrian-analysis of the faint Fraunhofer absorption lines of the corona be made in the radial as well as in the tangential vibrational direction. Such an analysis, which would make possible the determination of the polarization of the Fraunhofer spectrum, should preferably be made at the equator as well as the poles. Öhman made a first determination of the polarization of the Fraunhofer spectrum by this method in 1945.

2. The coronal Fraunhofer lines have been observed to become progressively more washed out as one proceeds from the outer to the inner corona. In the region of the coronal emission lines the Fraunhofer spectrum is virtually invisible. This phenomenon was observed in 1934 and attributed by Grotrian to the high electron velocities in the inner corona. A further search should be made for absorption lines in the inner corona; if any are present are they weak or strong, broad or narrow, etc.? What are their profiles?

3. Polarization of emission lines. Woolley and Allen (*M.N.* **108**, 301, 1948) conclude that at a height of 0·6*r* the coronal line of [Fe XIV], 5303 A., is excited half by electron impact and half by solar radiation, and that at larger heights the latter predominates. Zanstra has pointed out that this line should show the same theoretical polarization as the D_2 line of sodium (Heisenberg) amounting to 60% for light scattered perpendicularly to the incident beam. Therefore investigation of the polarization and its radial variation should provide a check on the hypothesis of Woolley and Allen for this line, and give additional information on the relative importance of radiation and collisional excitation of the coronal lines at various distances from the solar limb.

4. Further measures of the half-widths of emission lines and the radial variation thereof; to be correlated with measures of the radial intensity-variation of the various emission lines of the corona. Each of these should give a picture of the radial temperature gradient in the corona and it should be of especial interest to discover whether the two methods agree or disagree. And, in general, are the emission lines wider in regions of intense [Fe XIV] emission than in regions of [Fe X] predominance?

In this connection, I. S. Shklovsky (*Dokl. Akad. Nauk. S.S.S.R.* **63**, no. 1, 19, 1948) has called attention to the importance of measuring the half-width of the yellow coronal line, 5694 A., to discover whether this line comes from relatively cool or especially hot parts of the corona. The yellow coronal line 5694 A. appears only in regions of conspicuous solar activity. Edlén has tentatively attributed it to [Ca XV]; and Waldmeier favours this identification upon observing a predicted companion line at λ5446 A. However, Shklovsky finds no agreement between the theoretical and observed relative intensities of the two lines and therefore doubts the identification. One must note that the expected wave-length of the companion is very uncertain. A. Naqvi (Thesis, Harvard 1951) has predicted that the other member of [Ca XV] should appear around λ4567 A. where a faint line has occasionally been observed. A search should be made for this line at future eclipses. Further observations are needed also to establish the reality of other very faint lines reported in coronal emission.

Because of uncertainty as to the atomic weight of the element producing λ5694 A., the widths of known lines in the same region should also be measured. The relative widths of 5694 and 5303 A. in the same coronal region might give a clue to the atomic weight of the unknown line.

Radio Observations

1. Measurements of the intensity distribution and size of the source at the shorter wave-lengths in the radio spectrum. Measures should be obtained at as many wave-lengths as possible, especially below 10 cm.

2. Localization of bursts and point of origin on the solar disk, and correlation with optical features, and with data about the ionosphere.

3. Search for general solar magnetic field, especially at partial solar eclipses.

According to F Kerr, the Australians have decided that nothing can be learned from radio-eclipse observations that cannot equally well be observed without eclipse, with refined interferometric techniques. They therefore question the value of radio observations at eclipses.

G. G. Getmantsev and V L. Ginzburg (*J Exp. Phys. U.S.S.R.* **20**, 347, 1950) have discussed the possible use of diffraction of radio-waves on the Moon to improve resolution, and find that under favourable circumstances separations of the order of 2″ could be obtained. As this method requires a solar eclipse for application, it should be of interest to radio-eclipse observers.

Miscellaneous

1. Further measurements of the Einstein shift.

2. Geodetic measures and timing of the eclipse. Optical records of the time of covering of active areas have value for co-ordination with radio and ionospheric data.

Various astronomers have stressed the importance of general international co-ordination of eclipse work, usually without giving any specific suggestions, however. Mikhailov in his report to the President emphasizes the advantages of co-ordination between various eclipse observers. He recommends, especially for problems of the interrelations among various solar structures and formations, the use of standardized equipment, such as a series of identical coronographs distributed over the eclipse track. He also recommends a co-operative treatment of the resulting photographs. The President will welcome further specific comments and suggestions on the question of the international and inter-observatory co-ordination of solar eclipse work.

I wish to thank Dr Barbara Bell for her kind assistance in the preparation of this report.

DONALD H. MENZEL
President of the Commission

SUPPLEMENT TO THE DRAFT REPORT

1. N. G. Gussev carried out a correction of Lund's ephemeris by means of a measurement of arcs, obtained during the eclipse of 1941 with the standard coronograph.

2. The Astronomical Observatory of the Leningrad University published a detailed report of photo-electric observations of the total solar eclipses of 1941 and 1945, in the U.S.S.R.

N. N. Sytinskaya used a photographic method for the absolute photometry and colorimetry (in three different regions of the spectrum) of the inner solar corona. The instrument used was f 4·5, F=60 cm., and observations were made at the eclipses of 1941 and 1945. The structure of the solar corona was studied. V V Sharonov made colorimetric studies of the solar corona at the same eclipses.

V V Sharonov determined the integral brightness of the corona during the eclipse of 1941. The average value obtained from different methods was 0·067 lux (0·25 in illumination with respect to the Moon). Antipenko obtained the same value by a photographic method.

N. N. Sytinskaya summarized the observations of the brightness of the sky during the eclipse of 1941 by a group of participants of the expedition. The results are of importance for the reduction of the observations of the solar corona. During the eclipse of 1945 N. S. Orlova measured the sky brightness (in Sun's vertical), and O. M. Gromova measured the brightness of the afterglow ring.

3. M. A. Vashakidze carried out systematic measurements of the polarization of the corona during these eclipses:

(*a*) Eclipse of 1941. The polarization reached maximum in the equatorial zone at a height above the limb of 12′ and in the polar zone at a height of 6′ Thus maximum polarization depends on the position angle.

(*b*) Eclipse of 1945. The polarization does not depend on the wave-length. The polarization of rays is radial, therefore the plane of polarization does not rotate. In brighter and elongated parts of the corona the maximum of polarization is at a greater distance from the Sun's limb.

(*c*) Eclipse of 1952. In Archman (U.S.S.R.) twelve images of the corona through polaroids were obtained with a camera having three objectives.

4. A number of expeditions, both spectroscopic and photometric, observed the total solar eclipse of 1952 in the U.S.S.R. with success. Results of observations are under reduction.

5. V R. Viazanizin (*Publ. Pulkovo*, No. **147**, 19, 1951; ibid. No. **149**, 40, 1952) carried out extensive investigations on the absolute intensity of many spectral lines of the chromosphere and obtained the gradients of line intensity from spectrograms during the flash of 1941 and 1945 eclipses.

6. V U. Zuikov (*Publ. Pulkovo*, No. **149**, 47, 1952), from spectrograms of the prominences obtained during the 1941 eclipse, determined the excitation temperatures of the hydrogen (5600°) and helium (7300°) atoms.

7. V A. Krat investigated the spectrum of the chromosphere and the faint prominences obtained with quartz spectrographs during the 1945 eclipse. Appreciable deviations in the distribution of hydrogen and helium atoms from thermodynamic equilibrium were found (*Publ. Pulkovo*, No. **147**, 1, 1951).

8. V B. Nikonov and E. K. Nikonova (*Crimean Publications*, vol. 1, 83, 1947) obtained by the photoelectric method the total radiation of the solar corona during the eclipse 1945. The dependency of this radiation on the 11-year cycle of the solar activity was confirmed.

A supplementary bibliography of eclipse observations and computations has been prepared by the Japanese National Committee for Astronomy and has been sent to the members of Commission 13 in a mimeographed form. Most of these papers refer to the annular eclipse of 8–9 May 1948, in Reibun Island, and have been published in the following Japanese publications:

Tokyo Astronomical Bulletin.
Publications of the Astronomical Society of Japan.
Tokyo Astronomical Reprints.
Meteorology and Geophysics.
Report of Ionosphere Research in Japan.

Report of the meeting. September 1952, 9.30 a.m.

CHAIRMAN: D. H. MENZEL.

SECRETARY: H. C. VAN DE HULST.

The Chairman thanked all members and some non-members of the commission for their co-operation in submitting data for the preparation of the Draft Report. The Draft Report was accepted without comments or changes.

The Chairman then called for suggestions that might aid the commission in its work and the members in their research. He referred to the fact that as a result of a recommendation of the Commission, eclipse data are now available some eight years in advance instead of two. Redman suggested that data on weather conditions, etc., should be made available to prospective expedition members some two years in advance. This suggestion was adopted by the commission. A different Sub-commission will be appointed for each eclipse, with Prof. Redman as chairman and including members from the various countries on the eclipse track.

A brief discussion on rules for preparing the Draft Reports, in which Minnaert, Redman and Stratton took part, resulted in the decision 'that we like the Draft Report as it was this time and shall pass this opinion on to the Executive Committee'

The remaining time was devoted to brief reports on the observations made during the 1952 eclipse and some suggestions for future research.

1. Pecker reported on observations of solar radio emission. The intensity during totality was 0·20 and 0·31 times normal for wave-lengths 55 cm. and 117 cm. respectively. Limb brightening was observed on both wave-lengths.

2. Madwar reported on observations made in the Egyptian camp, in which also Atkinson and Lyot took part. Special attention was given to (*a*) photo-electric observations made by Rahman with a 10 cm. refractor that scanned successive circles around the Sun, the reductions have not been completed, (*b*) spectrographic observations made by Lyot and Aly with a curved slit, both in the ultra-violet and photographic regions. Some new ultra-violet lines are suspected, photometry is in progress.

3. Waldmeier called attention to a prominence that was seen in the polar region, elongated like a spicule and parallel with the polar rays of the corona. Its intensity diminished from the first to the last plates taken. Waldmeier suggested study of similar phenomena by (*a*) having many stations with identical instruments along the eclipse track and (*b*) having stations at the edge of the totality zone for also observing some low parts of the chromosphere during mid-totality.

4. Proisy pointed out that there is still a gap in the observational data on the limb darkening at the extreme limb of the Sun. Results of different authors are not in agreement. It was suggested that further observations should be made both by the method of total eclipses (Lindblad) and by that of partial eclipses (ten Bruggencate *et al.*).

5. Zanstra reported observation of the continuous spectrum of a prominence. Comparison of the spectrum at either side of the Balmer limit gave values of the order: $n_e = 10^{10}$ cm.$^{-3}$, thickness = 20,000 km.

6. Houtgast reported on the photometric spectra taken by the Utrecht party (Houtgast and Zwaan) in the range 3770–4900 A. Six good exposures were obtained at second contact; 300 lines can be measured. Some provisional results show the largest gradient for CN, the smallest for He^+, and equal gradients (intermediate) for neutral and ionized metals.

7 Redman summarized the programme that was successfully completed by the Cambridge party Von Klüber obtained good polarization photographs, Blackwell the colour and intensity distribution of the corona with a PbS cell, and Redman visual and ultra-violet spectrograms of the chromosphere with high dispersion.

8. Melnikov reported that many Russian observatories sent expeditions to observe the 1952 eclipse; the data are being reduced.

9. Menzel added that the High Altitude Observatory of Harvard University and the University of Colorado had a successful expedition.

https://doi.org/10.1017/S0251107X00032351 Published online by Cambridge University Press

The Chairman again stressed the importance of passing any suggestions of new problems or techniques on to the Commission. As a result, Houtgast asked whether predictions of the irregularities of the Moon's limb can be made for aiding the reduction of slitless spectrograms. Mrs Gossner, who is in charge of the prediction of eclipses at the Naval Observatory, said that Mr C. B. Watts at the same observatory was preparing maps of the lunar limb. Computations of the kind requested by Houtgast will be feasible in a few years. The regular eclipse computations have been completed for 1955 and 1956 and are in progress for 1957. A special pamphlet (supplement to *American Ephemeris*) for 1954 has been published.