13. COMMISSION DES ECLIPSES DU SOLEIL

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Since the previous Draft Report, two total eclipses of the sun have occurred, 25 February 1952 and 30 June 1954. The 1952 eclipse passed over central Africa, the Sudan, Arabia, Iran, and southern Siberia. The majority of expeditions concentrated near Khartoum in the Anglo-Egyptian Sudan, where they enjoyed clear skies and secured many valuable new observational data. The 1954 eclipse began in north-central U.S.A. and passed over Canada, Labrador, Greenland, Scandinavia, and the eastern half of the U.S.S.R. The weather was unfavourable over a large part of the eclipse track, and while some expeditions obtained observations, many others were clouded out.

H. von Klüber (1) has published two general reports on the various eclipse expeditions working at Khartoum in 1952. The former especially contains much detailed information concerning the programmes, the instruments and the scientists of the expeditions assembled in Khartoum. He has prepared a similar report (2) giving information on the various expeditions assembled in Sweden for the 1954 eclipse.

We call attention to the recent book, *The Sun*, edited by G. P. Kuiper (Univ. of Chicago Press, 1953). The chapters by H. C. van de Hulst on 'The chromosphere and the corona' and by C. W. Allen on 'Eclipse problems and methods' should be of particular interest to those concerned with securing and interpreting eclipse observations. Three photographs by G. van Biesbroeck (pp. 602–4) illustrate the maximum (20 May 1947) and minimum (25 February 1952) types of white light corona. A number of the results of the 1952 eclipse have been published in the *Atti del Convegno Volta* (Accademia Nazionale dei Lincei, Rome, 1953).

Because of the numerous new observations, the emphasis in the present report will be less on the theoretical side than in the previous report.

PROGRESS OF RESEARCH

Relativity displacement

Relativity displacement was measured by van Biesbroeck (3) at the 1952 eclipse at Khartoum. The National Geographic Society and the Military Air Transport System sponsored his expedition. Comparison plates were obtained on the site six months later at the same hour-angle. The eleven stars measured were well distributed around the Sun and the seeing was good, but windshake at the time of the eclipse made the images fuzzy and reduced the accuracy of the results. Van Biesbroeck writes that 'the result of $1''.70 \pm 0.10$ happened to be within 3% of the theoretical value, but it is quite uncertain owing to the quality of the images'.

Geometrical aspects of eclipses

A. A. Mikhailov (4) carried out preliminary calculations of the 1954 eclipse. He has also prepared a book, 'Theory of Eclipses', containing a new and simple method for the calculation of corpuscular eclipse and detailed tables for the calculation of solar eclipses.

R. d'E. Atkinson (5) has described his method for determining the Moon's place, relative to that of the Sun, by using a ciné-camera at a station just outside the belt of totality or annularity; and the application of the method at Mombasa (6) during the eclipse of November 1948. This method utilizes the fact that an observer stationed thus will see a thin crescent of uneclipsed solar surface even at mid-eclipse. The position

https://doi.org/10.1017/S0251107X00035562 Published online by Cambridge University Press

angle occupied by the crescent will change rapidly through a period of several minutes, at a rate of a degree in 2–6 sec. at mid-eclipse. An accurately timed sequence of exposures will give corrections to both lunar co-ordinates. He considers the method suitable for all geodetic work. Analysis of the Mombasa results (7) gives internal probable errors of ± 34 metres and ± 45 metres, in the two directions parallel to the fundamental plane; in angular units they are $\pm 0''.020$ in α and $\pm 0''.025$ in δ for (roughly speaking) the difference in the co-ordinates of Sun and Moon. Atkinson (8) also discusses a number of corrections which he considers should be applied to all eclipse work on the Moon's absolute place and has brought his suggestions to the particular attention of Clemence and Sadler for consideration in regard to the eclipse pages of the Almanacs.

At the 1952 eclipse Atkinson and A. H. Samaha of the Helwan Observatory undertook a joint programme at two stations 100 km. on either side of the line of totality in the Sudan, using the Atkinson method to photograph the thin crescents of the Sun near mid-eclipse and compare the measured position angle of the line of cusps with prediction. Greenwich sent two other expeditions, to Iraq and Kuwait, supported by the Iraq Petroleum Co. and Kuwait Oil Co. respectively. All except the Iraq station had clear sky, but because of poor seeing and other difficulties, Atkinson expects the results to be less accurate than at Mombasa. Two expeditions were sent to the 1954 eclipse, but obtained no observations because of clouds.

Atkinson has also written 'An introduction to the Eclipse Moon', which includes a bibliography of work on the geometrical aspects of eclipses, and is to appear in *Vistas in Astronomy*, the Stratton testimonial volume.

H. Kristenson (9) has published a note concerning the limitation on the geodetic eclipse methods which results from the inadequacy of available data on the details of the lunar limb contours seen at totality. He has determined lunar contours for the 1954 eclipse at six points along the central line. At the 1952 eclipse the Greenwich expedition took a number of large-scale pictures to obtain detailed lunar profiles at the librations existing during the eclipse.

Geodetic and time of contact determinations

J. M. Torroja (10) has made determinations of the instant of contact at the eclipse of 1952 in Spanish Guinea, and at the eclipse of 1954 on the island of Sydkoster, Sweden. He used a special camera in which the film moves continuously, with a uniform velocity of 72 mm./sec. Thus, instead of images, he obtains strips of different and variable density. The film contains a record of a reference light for standardization, time signals, and two records of the light-intensity variation of the eclipsed Sun: (i) an afocal photometric record of the variation of the integrated light of the whole eclipsed Sun, and (ii) a focal photometric record of a part of the solar crescent around the points of the contacts of totality. Since only one expedition was sent to each eclipse, the observations are useful for testing the method rather than for any geodetic purpose.

The path of the June 1954 eclipse made it especially interesting from a geodetic point of view. Many institutions, including the Geodetic Institute in Finland, the observatories of Lund, Stockholm, and Uppsala in Sweden, Rikets allmänna kartverk in Sweden, Ohio State University and the Aeronautical Chart and Information Center in the U.S.A., co-operated in sending more than 40 groups to take observations of contact times along the eclipse track. Three methods were to be used: the Bonsdorff method (direct cinematography), the Lindblad method (flash-spectrum cinematography, described in a previous Report), and the Heyden method (photo-electric record of light intensity). Unfortunately clouds obscured the Sun at most eclipse sites, so that no information useful for accurate determination of distances was secured by the first two methods. The sixteen groups using the light-intensity method all operated, but the presence of clouds at most stations considerably reduced the accuracy of their results. At Sydkoster, however, four methods (the three above and Torroja's) were used under not too unfavourable conditions by four separate expeditions, and the results should permit a useful comparison of the accuracy and possibilities of the different methods.

https://doi.org/10.1017/S0251107X00035562 Published online by Cambridge University Press

Limb darkening

At the 1952 eclipse near Khartoum, F. J. Heyden, C. A. Beck, D. J. Lovell, W. B. Fussell, J. H. Hancock, and E. O. Hulburt (11) obtained calibrated spectra of the light from the solar crescents near second and third contacts, photographed each $\frac{3}{4}$ sec. From these they determined the spectral intensity distribution from 3800 to 5800 Å which they found to be approximately constant over the outer 1·2% of the solar radius, and somewhat redder than at 5% in from the limb. They also obtained continuous recordings with photo-cells having a broad maximum of sensitivity at 7000–9000 Å, from which they determined the limb darkening over the outer 0·2% of the solar radius.

G. Righini reports that observations of the limb darkening at the partial solar eclipses of 1 September 1951 and 30 June 1954 were taken using the solar tower at Arcetri. The continuum was observed in seven 'windows' between the lines, in the wave-length range 4365–6507 Å. The resulting darkening curves, corrected for scattered light, agree with those given by ten Bruggencate except in the range $0{\cdot}007 > 1 - \sin\theta > 0$, indicating that the drop of intensity at the extreme edge of the Sun was not observed.

Photospheric and chromospheric intensity gradients

On the island of Koster, H. Kristenson and L. Stigmark of the Lund expedition obtained good records for the geodetic programme; and with a camera of higher dispersion Kristenson obtained additional material for the analysis of intensity gradients of some twenty-five of the strongest chromospheric lines, and the law of limb darkening in the region extending from the limb some 5–10 sec. of arc towards the centre. In the same expedition A. Reiz obtained material for measuring the decrease of intensity at the extreme solar limb in the continuous spectrum as well as in the lines of hydrogen, and for determining the intensity gradient in the corona.

Intensity gradients in the chromosphere and photosphere, determined by means of cinematography at the eclipse of 9 July 1945, have been discussed by B. Lindblad and H. Kristenson (12), and later in detail by Kristenson (13). The value of β, in the expression $I = I_0 e^{-\beta h}$ for the variation of intensity I (not corrected for self-absorption) with the height h, lies between $1{\cdot}33 \times 10^{-8}$ and $2{\cdot}12 \times 10^{-8}$ cm.$^{-1}$ for the Balmar lines, H_β through H(16). The He lines λ4472 and 5878 and the H and K lines of Ca II show much smaller gradients than the Balmer lines. For the continuous spectrum at the extreme limb they found the following gradients: $\beta\,(\lambda 4400) = 6{\cdot}4 \times 10^{-8}$, $\beta\,(\lambda 3660) = 4{\cdot}1 \times 10^{-8}$ and $\beta\,(\lambda 3600) = 3{\cdot}6 \times 10^{-8}$ cm.$^{-1}$. The solar limb thus appears more diffuse when viewed in ultra-violet than in visual light.

Expeditions organized from Uppsala, Stockholm, and Lund Observatories for the 1954 eclipse had planned cinematographic photometry of the intensity gradients in the extreme photosphere and in the chromosphere, as well as exact time of contact determinations. But all three were clouded out.

J. Houtgast and C. Zwaan, on an expedition sent out by the Netherlands Eclipse Committee, used a slitless Cooke-camera ($f = 270$ cm.) with two flint prisms of 45° to study the flash spectrum at the eclipse of 1952. At each contact they obtained six exposures on a jumping plate, covering the spectral region 3770–4880 Å. Standardization spectra were taken which permit the line strengths to be obtained in absolute intensities. They have published (14) provisional values of the gradients of the relative intensities of some 30 selected emission lines as a function of height in the chromosphere. In all about 130 lines are being measured on the first four exposures at second contact at several points in the line crescents. They find that the gradient is smallest for He^+ lines, where the line intensity decreases by a factor 10 when the Moon's limb moves from level 0 to 3000 km. height; and is greatest for the CN band at 3883 where the same decrease occurs between 0 and 400 km. height. Intermediate to these are, in order of increasing steepness, the gradients of lines of He, H, Mg, atoms of other metals (Fe, Mn, Cr, Ca), and metal ions (Fe^+, Ti^+, Sc^+, Sr^+).

At the eclipse of 1954 the development of the flash spectrum was studied by J. Houtgast, assisted by J. F. Heintze, by means of the prismatic camera already used in 1952. 133 spectra were recorded on jumping film, with three exposures per 2 sec. and an exposure time of 0·1 sec. A variable diaphragm regulated the intensities so that about ten of the strongest lines can be well followed throughout the flash, their photographic densities remaining moderate. A complete system of calibration spectra was taken and reduction of the observations is in progress.

An expedition from the High Altitude Observatory of Harvard University and University of Colorado, led by J. W. Evans and supported by the Office of Naval Research, carried out optical observations of the flash spectrum in co-ordination with radio-noise observations by the Naval Research Laboratory at the 1952 eclipse. The H.A.O. programme was designed to observe the spectral range from 8800 to 3400 Å, with jumping-film slitless spectrographs giving a height resolution of 110 km. in the chromosphere below 2500 km. At first flash 16 to 21 spectrograms were obtained in each of three spectrographs. The infra-red spectrograms were under-exposed, and only the strongest lines were usable on most of them. An image divider, which gave a secondary image of the spectrum at reduced intensity, greatly extended the range of usable data, and was a valuable aid in determining the characteristics of the films.

Results for the Balmer lines of hydrogen have been published by R. G. Athay, D. E. Billings, J. W. Evans and W. O. Roberts (15). Their paper gives intensities of H_4 through H_{31} (H_7 missing) at four wave-lengths in the Balmer continuum, and at $\lambda 3700$ and 4700. Intensities of H_β are given at twenty heights between 530 and 6300 km. The intensities of the high series members and the Balmer continuum are given at fifteen heights between 530 and 2400 km. The values of β range from $1{\cdot}56 \times 10^{-8}$ for H_β to $1{\cdot}73 \times 10^{-8}$ at H_{16} and $2{\cdot}12 \times 10^{-8}$ at H_{30}. Analyses of He and metal-line observations are in progress.

Interpretation of the H.A.O. hydrogen-line data has been approached from three separate points of view (16) (17) (18), each leading to essentially the same conclusions: (i) the Balmer line intensities are strongly affected by self-absorption, and (ii) marked departures from thermodynamic equilibrium occur, in the sense that populations of levels above the ground state are greater than would be expected under thermodynamic equilibrium. The departures increase with height in the chromosphere.

Athay, Evans and Roberts (19) have discussed the behaviour of hydrogen and helium in the active region observed at P.A. 260° during the 1952 eclipse. They find a marked strengthening of He II 4686 both absolutely and relative to 4713 of He I. The coronal line 5694 is also present. Athay and Thomas further report that they find clear indications that chromospheric conditions vary from one eclipse to another, particularly in comparing the 1952 H.A.O. results with the 1932 results of Cillié and Menzel. However, the detailed pattern of the time variation appears as yet far from clear.

At the 1952 eclipse V. P. Vyazanitsyn (20) obtained good spectrograms of the chromosphere from which he has determined the absolute intensities of the chromosphere lines and the gradients of emission. He points out an inhomogeneity of the gradients of the emission lines along the limb of the Sun and an anomaly in the gradients of the D_3 lines of He. From a comparison of his results with the data from other eclipses, he finds evidence of a change of gradients in the course of an 11-year cycle. V. A. Krat (21) has also discussed the problem of chromospheric variability.

Flash spectrum

The Dominion Observatory-National Research Council expedition (22), under P. Millman, obtained satisfactory flash spectra, with a slit spectrograph, range 2900–6600 Å, dispersion 20–130 Å/mm. This was an airborne expedition, flown by the Royal Canadian Air Force, over the Labrador Coast at an altitude of 27,500 ft. Reduction of the flash spectra is in progress.

Clouds prevented observation of the flash spectrum by three other Canadian expeditions (23), from the David Dunlap Observatory, the Dominion Astrophysical Observatory, and the Dominion Observatory (ground expedition). The Arcetri Observatory sent an expedition to observe the flash spectrum at Öland, where clouds prevented observations. Study of the 1952 flash spectrum is in progress by Righini at Arcetri and should soon be completed (24). K. Araki (25) has published a calibration of Mitchell's intensity scale of chromospheric lines, in terms of the absolute intensities of Cillié and Menzel.

Widths of chromospheric lines

R. O. Redman (26) used the second order of a 6-inch Rowland concave grating in a Wadsworth mounting at the 1952 eclipse to photograph the flash spectrum in the yellow at second contact and in the ultra-violet at third contact. He writes that the 1952 observations confirm those of 1940 that there is little turbulence at the base of the chromosphere, and provide evidence of an increase in the line-of-sight velocity with chromospheric height which needs further investigation. A discussion with Z. Suemoto shows that early members of the hydrogen Balmer series are affected by broadening from self-absorption, the later members from Stark effect. When these causes of broadening are removed, the corrected line-widths indicate that the kinetic temperature in the lower chromosphere is not greater than 10,000° K. and may be as low as 6000°. He considers it unlikely that present data on line-profiles can give more accurate measures of the temperature than this (papers in the Press). At the 1954 eclipse, Redman obtained high-dispersion slit spectrograms in the ultra-violet (~ 1 Å/mm.), but succeeded in photographing only the strongest lines because of thin clouds. D. W. Dewhirst obtained ultra-violet spectrograms to measure the chromospheric electron temperature by Zanstra's method.

Because of the importance of measuring accurately the widths of chromospheric lines of various atomic weights, including the narrow lines of heavy metals, to determine the relative contributions of temperature and turbulence, H. A. Brück and D. A. Jackson (27) decided to investigate the possibility of making the observations with a Fabry-Perot interferometer, at the eclipse of 1952. They have published a description of the instrument and methods as well as the results of their attempt. Brück (28) has also published a description alone. They did not obtain any positive results because they could photograph only the strong lines, which are probably distorted by self-reversal. But they showed that interferometric methods can be applied to eclipse work, and they planned to repeat the experiment at the 1954 eclipse using larger equipment. At the 1954 eclipse they had a 16" coelostat, a 15" $f/8$ mirror telescope and an $f/8$ two-prism glass spectrograph, with a Fabry-Perot interferometer of the multilayer type. The etalon plates had five layers, 2·5 mm. apart, corresponding to a resolving power of 220,000. This instrument, to be used in the blue spectral region, was capable of reaching lines fifty times fainter than those photographed at Khartoum. Therefore, if the weather had been favourable, they calculate they should have been able to measure widths of non-reversed faint lines.

Chromosphere model

From the 1952 H.A.O. eclipse observations, R. G. Athay, J. C. Pecker, R. N. Thomas and D. H. Menzel (29) have analysed the Balmer and continuous spectrum intensities to derive a model of the chromosphere. In the Balmer lines they find strong effects of self-absorption and large departures from thermodynamic equilibrium, the latter increasing with height in the atmosphere. From continuum intensities at $\lambda 4700$, extending over the height range -120 to 48,500 km., and intensities on both sides of the Balmer continuum, they have determined the kinetic temperature and electron density as a function of height in the chromosphere. The temperature model may be divided into three regions with the following properties:

(1)	$-120 \leqslant h \leqslant 500$ km.	T_e increases from $\sim 4800°$ to $\sim 5800°$ K.
(2)	$500 \leqslant h \leqslant 3000$ km.	T_e increases slowly from $\sim 5800°$ to 6800° K.
(3)	$3000 \leqslant h \leqslant 6000$ km.	T_e increases rapidly from $\sim 6800°$ to $\sim 70{,}000°$ K.

https://doi.org/10.1017/S0251107X00035562 Published online by Cambridge University Press

The model requires an energy source external to the chromosphere, and the internal energy per gram rises smoothly through the chromosphere. In contrast to conditions in previous chromospheric models, the ionization of hydrogen occurs principally (0·03 to 0·90) in region (2); the temperature here rises slowly because the energy dissipated from the external source is absorbed mainly as ionization energy rather than kinetic energy. Below 2000 km. the conditions of hydrostatic equilibrium are very nearly satisfied, but above 4000 km. the electron pressure increases with height. Electron densities have been derived for heights up to 50,000 km.

Athay and Pecker (30) have studied the band of CN at $\lambda 3883$ Å. They find a rotation temperature of 4500° at 100 km. and evidence of an increase in temperature with height. The absolute intensity of CN and the scale height ($\sim$210 km.) agree, within the accuracy of the determinations, with the above model derived from the continuum. For CN a dissociation potential around 11 volts is indicated.

S. Matsushima (31) has discussed collisional excitation in hydrogen from levels other than the lowest. I. Kawaguchi (32) has published a study of the population of the hydrogen atoms in the second state in the chromosphere. On the basis of earlier work by Giovanelli, J. T. Jefferies (33) has discussed the emission of Hα and Lyman radiation from model solar atmospheres consisting of a photosphere and an overlying chromosphere which scatters coherently and which is isothermal at one of a number of kinetic temperatures in the range 10^4 to 2.5×10^5 ° K. J. H. Piddington (34) has published a summarizing discussion of a number of model solar chromospheres and the problem of reconciling radio and optical results.

Radio noise

Observations of the annular solar eclipse of 1 September 1951 in the French Sudan are reported by E. J. Blum, J. F. Denisse and J. L. Steinberg (35). On 3·2 cm. the distribution of brightness across the disk showed some limb-brightening, in agreement with a theoretical curve based on a strong temperature gradient in the chromosphere. The occultation of an area active in this wave-length occurred simultaneously with the visual occultation of a sunspot. They therefore conclude that the active area, of temperature $\sim 6 \times 10^5$ ° K. at 3·2 cm. was localized about the visible spot. At 178 cm. the mean diameter of the solar disk was 35% greater than the visual diameter and showed a marked departure from circular symmetry in the sense of an equatorial diameter larger than the polar diameter.

Further observations (36) at 178 cm. at the eclipse of 1952 indicate that 9% of the total radiation was occulted at first and fourth optical contacts, an amount incompatible on a spherical model with the residual 48% of radiation observed at maximum of the eclipse. They find that a model of the Sun as a uniformly bright ellipsoid is able to reproduce the observed variation to an accuracy of 2%.

M. Laffineur, R. Michard, J. C. Pecker, M. d'Azambuja, A. Dollfus, and I. Atanasijevic (37) have published a summary of the instruments used and the results obtained on visual and radio wave-lengths (55 and 117 cm.) by the expedition of the Bureau des Longitudes at the 1952 eclipse, including observations with the radio telescope at Meudon. They find that an interpretation of the asymmetries of their curves is possible with the aid of photometric data on the monochromatic and white-light corona.

K. Aoki (38) has published observations made at Tokyo of the partial eclipse 14 February 1953 at a wave-length of 10 cm. for a fairly quiet Sun. At this wave-length the Sun was 5% larger than the visual disk and showed a limb-brightening. Asymmetry in the observed eclipse curve is explained by a local bright region around the sunspots, which is interpreted as an excess of the electron density in the chromosphere and the corona.

The radio-astronomical Observatory of Chalmers Technical University, Göteborg, was favourably situated close to the ionospheric central line of the eclipse of 1954. O. Rydbeck obtained extensive records of the radio intensity in various wave-lengths during the entire phase of the eclipse. N. Hansson of the Lund expedition at Koster measured the radio intensity of the corona at 1·6 m.

Under M. Ryle observations were made of the partially eclipsed Sun at Cambridge, on wave-lengths 0·6, 1·4, 1·7, 3·7 and 7·9 m., to check and supplement results obtained with interferometers on the uneclipsed Sun.

R. Coutrez, A. Koeckelenbergh and E. Pourbaix (39) have published results from observations at three African stations during the 1952 eclipse, and they discuss the identification of localized sources of enhanced radiation on 169 Mc.

The Naval Research Laboratory sent expeditions to the eclipses of 1952 and 1954, to observe radio noise on wave-lengths 9·4 and 0·85 cm. As J. P. Hagen points out, the principal value of centimetre-wave eclipse observations lies in the high effective angular resolution possible, approaching optical values. Since the centimetre Sun is nearly the size of the Moon, they also offer the possibility of determining a precise radial scale of electron density and temperature in the chromosphere. On the other hand, at metre wave-lengths, where the radio Sun is much larger than the Moon, one cannot obtain precise values.

Hagen reports that although the 1954 eclipse data at these wave-lengths is still being analysed, the results appear to indicate that there were no localized sources of enhanced emission on the Sun during the eclipse, making this eclipse especially suitable for determination of the general brightness distribution. Preliminary 1954 results at 9·4 cm. require a pronounced limb-brightening such as that predicted by idealized thermal models of the Sun's atmosphere. They further indicate both that the intensity of radio flux from the undisturbed Sun has decreased, and that the size of the radio Sun has decreased a few percent from the 1952 data. The 8·5 mm. data also require limb-brightening as predicted by theory, but this curve provides a result which will require a modification of conventional model chromospheres. N.R.L. investigations have also yielded information on the proportionality between the enhanced 3 cm. flux and the total sunspot area on the visible disk.

Corona

C. W. Allen (40) has published a review on 'The physical conditions of the solar corona'.

Coronal emission lines

A study of the spectra of the solar corona obtained at the 1952 eclipse by the late Bernard Lyot (41) (42), assisted by M. K. Aly of the Helwan Observatory, has been published. The spectrograms covered the wave-length range 3000–6800 Å, and include 262 lines from a prominence. Lyot and Dollfus found all (18) of the usual coronal lines, except 4311, and in addition they found four new lines 3534, 3997, 4351, 4412, and possibly a fifth line at 4570. They confirmed the existence of the 5445 line, first observed by Waldmeier in 1950. The distribution of the line intensities in four coronal streamers permitted the classification of the lines into four groups, entirely compatible with Edlén's identifications.

At the same eclipse G. Righini (43) obtained spectra of the corona covering the range 3300–8000 Å, which show fifteen of the well-known lines but no new lines. Comparing these 1952 spectra with those taken in 1936 with the same instrument, he notes that the lines 3388 and 3454 are much weaker in 1952 than in 1936, while 3986 was strong in 1952 and absent in 1936, and 3533 was strong in 1936 and missing in 1952.

The Astrophysical Institute of Liège University sent an expedition under M. Migeotte and B. Rosen to Holmhällar (south Gotland) to observe the spectrum of the corona in the ultra-violet. They obtained three spectra with the slit oriented tangentially to the solar equator and covering a region up to 14′ from the solar limb. Preliminary results give evidence of four new coronal emission lines, 4055, 3885, 3180 and 3010 Å. According to a private communication to Migeotte and Rosen from B. Edlén, the strongest of these, at 3010, fits the predicted position for Fe XII $3s^2 3p^3\ {}^2P_{\frac{1}{2}} - {}^2D_{\frac{3}{2}}$, within the error limits of the extrapolation. They note that the unidentified line at 3454 appeared to be much stronger than the Fe XIII line at 3388.

Edlén's long-controversial identification of the yellow coronal line, $\lambda 5694$, as arising from the transition $1s^2 2s^2 2p^2\ {}^3P_1 - {}^3P_0$ in Ca xv, and Waldmeier's subsequent assignment of the line $\lambda 5445$ to the transition ${}^3P_2 - {}^3P_1$, have recently been confirmed in a semi-theoretical investigation by D. Layzer (44). Independently and using a different method, Edlén (unpublished) has reached the same conclusion.

H. von Klüber, in collaboration with A. H. Jarrett (45) of St Andrews University, used a narrow band interference filter combined with a multi-coated interferometer to investigate the green coronal line at the 1954 eclipse. In spite of the very low intensity of the green line during the present phase of the solar cycle and the moderate seeing during the eclipse, about a dozen interference fringes covering the image of the corona could be traced on the films. They hope that some information concerning the behaviour of the line-widths in different parts of the corona can be deduced from the photographs. Von Klüber writes that by improving this method it should be possible to obtain a photographic image of the whole corona during an eclipse, with a system of interference fringes from the green and from the red line simultaneously. Since he will be unable to continue this experiment, he hopes that others may be interested in doing so, if possible at the 1955 eclipse.

The French expedition of the Bureau of Longitudes, at Khartoum, obtained photographs of the monochromatic corona, 5303 and 6374, by means of a Lyot filter. Millman's airborne expedition obtained spectra of the corona with a slit spectrograph covering the range 2900–6600 Å with a dispersion of 20–170 Å/mm. (op. cit.). This expedition also made a report on the form of the corona and position of prominences, for international broadcast to scientific expeditions in Sweden prior to the occurrence of the eclipse there. K. Saito (46) has published spectroscopic observations of five coronal and six prominence lines in the visual region obtained at the total eclipse of 21 September 1941.

Athay and Roberts (47) have made a study of the coronal lines on the H.A.O. spectrograms. They measured the intensities of three coronal lines, 5303, 6374 and 7892, and of the continuum at fifteen position angles on the limb. They found the correlation between the line and continuum intensities to be markedly higher for 5303 than for either 6374 or 7892, in accord with earlier observations by Menzel. The relative intensities of lines and continuum indicated that active regions are characterized by both higher density and temperature than are found in quieter regions. In two of the quieter regions they obtained curves of intensity versus height for 7892 from 3000 to 50,000 km. These data indicated that the maximum coronal line emission occurred below 10,000 km. at the time of the 1952 eclipse. They point out that the presence of coronal line emission near the upper levels of the chromosphere supports the concept of high temperatures in the upper chromosphere given by the H.A.O. model of the chromosphere.

It would appear that the high temperatures in the upper chromosphere derived from the optical data cannot be reconciled with the radio-noise data, without either assuming a non-uniform structure consisting of regions of different temperatures and densities, or revising the theories of radio-noise emission. In this connexion Athay and Roberts note that their spectrograms actually show definite spicule structure in the chromosphere above 5400 km. and extending in Hα to about 8500 km.; this non-uniform structure was not observed below about 5400 km. From radio-noise observations Hagen also finds evidence for a non-uniform structure.

Von Klüber (48) has compared the shape of the 'white' corona, obtained from his 1952 eclipse plates, with the observations made simultaneously by various Lyot-coronagraphs. He calls particular attention to the long and intense white-light streamer at a position angle of 70°. Following the idea of Allen (49) that white-light streamers may be identified with corpuscular streams from the unidentified solar sources of recurrent geomagnetic storms, von Klüber suggests that this streamer may have been the cause of the geomagnetic storm starting 4 March after central meridian passage of the streamer. R. Müller (50) has published the intensities of 5303 and 6374 observed at Wendelstein on 30 June 1954.

At the eclipse of 1952, A. Colacevich (51) used a spectrograph with a special slit of variable width designed to give a constant photographic density on the continuous spectrum of the corona when placed radially to the solar limb. He made a single exposure of 170 sec. of good density around H and K, with the slit located at 75° P.A., just off the centre of the principal white-light streamer at 70°. He found the emission lines K, H, 3908, Hζ and 3765, extending out as far as 70′ or more than two solar diameters from the solar limb; and beyond this no trace of any emission or absorption lines up to 2° from the limb. Because of uncertainty whether he may have by any chance observed a local phenomenon or a general feature of the corona, he points out the desirability of making similar observations at future eclipses.

Coronal absorption spectrum

At the 1954 eclipse M. Minnaert, assisted by N. van Straten, photographed the spectrum of the inner corona in an attempt to detect hazy depressions in the continuum, corresponding to the H and K lines and to other line groups in the near ultra-violet, greatly broadened by the rapid motion of the scattering electrons. The slit of the instrument was trifold, the central slit being tangential to the solar image, the two others intersecting radially the corona. A set of comparison plates was taken, for which the Sun's light was reduced in a proportion of about 1:500,000. This reduction of intensity permitted the taking of comparison spectra with the same exposure times, slit widths, etc., used for the corona. The eclipse spectra possessed densities well suited for microphotometry. Preliminary examination reveals no trace of any H and K depressions. Righini writes also that no trace of the Grotrian dip near H and K can be observed in the Arcetri coronal spectra from the 1952 eclipse. These observations substantiate the earlier results of Shajn and Menzel (52).

Migeotte and Rosen report they have found and studied in detail some anomalies in the intensities of the Fraunhofer lines in the F corona. They suggest these anomalies might be attributed to the existence of a 'diffuse protuberance' surrounding the Sun, in conformity with the hypothesis made by Colacevich as a result of his observations of the 1952 eclipse. They point out the need, however, for further study of this interpretation.

Coronal photometry

A. B. Severny reports that the integral brightness of the corona was measured by means of visual photometers in 1952 by N. N. Sytinskaya and A. K. Suslov (53) on the expedition of Leningrad University. The brightness of the corona was 6×10^{-7} that of the Sun. Analogous measurements were carried out by A. K. Sosnova (54) of the Stalinabad Observatory, who found that the relative brightness of the corona equalled 0·789 that of the Moon.

J. M. Ramberg (55) has continued his work on the photographic and photovisual photometry of the corona. He has now investigated the distribution of intensity in the intermediate-type corona observed at the eclipse of 21 August 1914. He has found that in the 1914 corona the change from increasing to decreasing flattening takes place at exactly the same value (1·75 solar radii) of the equatorial radius of the isophotes, as he found in the corona of 1945 (56). Furthermore he found that in regions undisturbed by prominences, the radial intensity gradient is practically the same in corresponding position angles in the corona of 1914 and that of 1945, in spite of the considerable difference in the flattening of the corona on the two occasions. However, the two eclipses occurred at comparable phases of the solar cycle.

M. Waldmeier (57) has made a photometric study of the 1952 corona. He finds that the ellipticity of the coronal isophotes shows a maximum at about 1·8 and then decreases with increasing distance from the Sun's limb up to $R = 4{\cdot}5$. At still larger distances the ellipticity increases again, and he suggests that this outermost component of the corona represents the innermost part of the zodiacal light. M. Cimino (58) has also published photometric and polarimetric observations of the solar corona made at the 1952 eclipse.

B. A. Lindblad reports that ideal weather for observing the 1954 eclipse occurred only on the southern part of the island of Gotland, where A. Wallenquist obtained excellent photographic material for photometry of the corona. Analysis of the plates is in progress at the Uppsala Observatory. At the island Koster, Lindblad recorded the extreme parts of the corona in the infra-red; and G. Larsson-Leander (Stockholm) obtained photometric plates of the corona in the yellow spectral region. Clouds prevented the success of E. Holberg's Lund expedition which had planned photometry of the corona at Lake Vättern. Clouds also prevented the success of the Stockholm Observatory's expedition at Öland, where Ramberg had an extensive programme on the corona, comprising direct photometry of the corona in different spectral regions and in the infra-red with lead-sulphide cells, and also spectrophotometry of the corona. O. Wiberg had arranged for general photometry of the corona with instruments of his own.

The University of London Observatory sent an expedition to Syd Koster, Sweden, to make a photometric study of the outer corona by both direct photography and low dispersion spectroscopy. The chief feature of the observing technique was the introduction of an occulting disk or bar into the optical system to make the intensity of the inner corona comparable to that of the outer corona. While the photometric accuracy of the observations was much reduced by the presence of thin cloud, some estimates of the brightness, ellipticity and colour to a distance of 12 radii have been reduced from the direct coronal photographs. Allen writes that they plan to send similar instruments to Ceylon for the 20 June 1955 eclipse.

Coronal colour

At the 1952 eclipse D. E. Blackwell (59) measured the corona in the infra-red with a lead-sulphide cell and in the violet with a photomultiplier. He found a considerable excess of infra-red radiation at 2·5 radii from the Sun's centre and showed that this result supports the theory of an F-corona caused by interplanetary dust particles. However, the observations cannot discriminate between models with rather widely differing distributions of dust. At the 1954 eclipse Blackwell photographed the outer corona through the open door of a plane at 30,000 ft., using a multiple camera especially designed to give little false light. The photographs, in red light and some through polaroid, have been measured to 50 radii.

Radiometric measurements of the corona, intended for determinations of the infra-red excess of the corona relative to the solar light, were carried out in 1952 by M. S. Zeltzer, and in 1954 by J. I. Lumsishvili and N. L. Magalashvili. According to the 1952 data no excess was observed. V. V. Sharonov (60) found that during the eclipse of 1952 the corona was redder than the Sun by about 0·098 units of colour index.

M. Fracastoro (61) has published a detailed photometric study of the 1952 corona. From the isophotes of the corona he has deduced the variation of the coronal radiation as a function of the distance h from the solar limb, for three spectral regions. He concludes that the colour variations are very small with increasing h and in large part are due to an incomplete valuation of the diffuse light. Comparisons with the standard lamp used for calibration of the plates gives the colour index of the inner corona (violet-green $=0{\cdot}76^{m}$; violet-red $=2{\cdot}43^{m}$). He shows that the prominences contribute significantly to the diffuse light in the red. He also gives a critical discussion of the results obtained in preceding eclipses, and considers especially the validity of the various methods employed to take account of the diffuse light. Three-colour photometry of the corona in 1954 was planned by the Arcetri Observatory but clouds prevented successful observations.

Polarization of the corona

J. C. Pecker writes that the French expedition of the Bureau of Longitudes at Khartoum used six cameras of different characteristics to obtain photographs of the corona in the red and in polarized light. Isophotes of the outer corona, up to 12 solar radii from the solar limb, have been obtained and the intensities expressed relative to that of the photospheric disk. The measures of polarization have been made at different points, particularly in the large coronal streamer. Colacevich has also studied the polarization of the 1952 coronal streamers.

M. A. Vashakidze and M. G. Kolkhidashvili (62) obtained data concerning the polarization in various parts of the corona during the eclipse of 1952. They have studied the relation between the sunspots and the degree of polarization from the limb of the Sun, and graphs are given.

During the 1952 eclipse at Khartoum under very good weather conditions von Klüber obtained twenty-four calibrated photographs of high quality, mostly through sets of polaroids. The measurements of these plates is not yet completed, but von Klüber writes that he hopes very accurate values of the intensity, polarization and direction of polarization of the coronal light can be derived from them.

Dr Abd-el-Rahman of Helwan Observatory, using an instrument designed at the Leiden Observatory, obtained photo-electric records of the outer corona for determination of its intensity and polarization. The David Dunlap Observatory planned to observe the coronal polarization at the 1954 eclipse, but were clouded out.

Coronal structure

Severny writes that a large amount of data was obtained in 1952 and 1954 by various Soviet eclipse expeditions on the photometry and structure of the corona. Using data obtained during the 1952 eclipse, E. J. Bugoslavskaja (63) compared the details of the structure of the corona and the intensities of the coronal lines with the formations in the lower layers of the solar atmosphere. The author's previous results (64) were confirmed. The direct rays stretch over the facular fields, whereas the helmet-like currents are related to the prominences. Maximum intensities in the green line appear to correspond to the facular fields, the red line appearing more intense above the spots. She finds that the curvature of the polar rays departs from that of the magnetic lines of force from a homogeneous magnetic sphere with a dipole field.

G. M. Nicolsky (65) has studied photographs of the 1952 corona and pointed out that they showed the polar regions to be extremely bright and extended. He attempts to identify the coronal rays with the corpuscular currents emitted by the Sun. He has also carried out the photometry of the large coronal ray and calculated the decrease of the electron density and the dissipation of the rays.

Abetti (66) has investigated the existence of the general magnetic field of the Sun and attempted to locate the position of the Sun's magnetic poles from study of the shape and curvature of the polar rays of the corona observed at several eclipses. Assuming the position of the magnetic poles to be defined by the axis of symmetry of the polar rays of the corona, he concludes that 'the hypothetical magnetic poles are not antipodal and also they do not coincide with the rotation poles'.

Zodiacal light

At the eclipse of 1952, W. A. Rense, J. M. Jackson and B. Todd (67) obtained photographs of the skylight in the vicinity of the eclipsed Sun at a point in the shadow path near the Red Sea, at an altitude of 32,000 ft. above Saudi Arabia. From a photometric analysis of the photographs they obtained information about the intensities and degree of polarization of the zodiacal glow between 5°·5 and 13° from the Sun. The data are consistent with the planetary dust-cloud theory of the origin of the light and help to tie in previous observations of the glow beyond 30° from the Sun with those of the solar corona within 3° of the Sun.

At the 1954 eclipse van Biesbroeck, R. Weitbrecht and T. Gehrels of the Yerkes Observatory went to a site in eastern Colorado where the eclipsed Sun was 2° below the horizon at totality. The expedition, sponsored by the National Geographic Society, sought to explore the possibility of making photometric measures of the brightness of the inner zodiacal light. Clouds prevented actual measurements. But van Biesbroeck (68)

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writes that there was enough clear sky to record the shadow, and they concluded that the twilight, even cut down by the eclipse, would still have been much too bright to allow recording the zodiacal light.

Prominences

At the 1952 eclipse H. Zanstra (69) photographed the ultra-violet spectrum of a prominence. From the continuous spectrum, assuming a prominence temperature of 5000°, he finds the electron concentration of $0{\cdot}7 \times 10^{10}$ per cm.^{3} and the prominence thickness 40,000 km. For an assumed temperature of 15,000°, these figures become 5×10^{10} and 6000 respectively. Other analyses of conditions in prominences observed at earlier eclipses have been made by S. G. M. Haug (70) and by D. Koelbloed (71).

G. Thiessen (72) has published a discussion on the theory of the polarization of Hα and D_3 in prominences, and has tabulated the expected values for various lines, heights, and orientations of the magnetic field. V. A. Krat (73) has discussed the spectrum of a weak prominence observed during the 1945 solar eclipse.

On the 1954 Stockholm expedition to Öland, Y. Öhman had an extensive programme for investigating the corona and prominences. The inner corona was to be studied with red and blue filters for eventual dark structures, with an interference filter isolating Hα for prominences and another at about 4780 Å where the prominences have no strong emission lines. Because of clouds only a few plates were obtained.

Terrestrial upper atmosphere

Millman's airborne expedition made a visual search for daytime aurora, with negative results. Menzel, J. G. Wolbach and H. Zirin, observing the eclipse from a Northwest Airlines stratocruiser, also searched for daylight aurorae with negative results. Minnaert reports that A. C. S. van Heel, from the Polytechnical Highschool at Delft, with his assistants Beernink and Einthoven, made an attempt to film the shadow-bands, just before and just after totality, with the aim of studying the atmospheric turbulence. Using a specially designed instrument, they obtained some films that clearly show passing striae. The striae have wave-lengths of the order of 10 cm. and speeds of about 2 m./sec. The contrast is faint.

Notuki reports that Y. Nakata (74) has made ionospheric observations during the partial solar eclipse of 14 February 1953 at Kokubunji, Tokyo. The magnitude of obscuration was 0·528 at 300 km. above the ground; h′f records were obtained with an automatic multifrequency equipment which sweeps through a frequency range from 1·8 Mc./sec. to 15 Mc./sec. in 30 sec. The measurements during the eclipse were carried out every minute.

Future Work

Coming total eclipses

Date	Max. duration (min.)	Where visible
20 June 1955	7·1	Ceylon, Thailand, Indo-China, Philippines
8 June 1956	4·6	South Pacific Ocean (no land)
23 Oct. 1957	—	South Atlantic (non-central total eclipse)
12 Oct. 1958	3·5	Pacific Ocean; a few Pacific atolls
2 Oct. 1959	3·0	Rio de Oro, French West and Equatorial Africa, Ethiopia
15 Feb. 1961	—	Southern Europe, U.S.S.R.

Coming annular eclipses

Date	Max. duration (min.)	Where visible
14 Dec. 1955	12	Sudan, Somaliland, Indian Ocean, Thailand
29 Apr. 1957	—	Arctic Ocean, north of Scandinavia
19 Apr. 1958	7	Thailand, South and East China Seas
8 Apr. 1959	7·4	Australia, south-west to north-east

https://doi.org/10.1017/S0251107X00035562 Published online by Cambridge University Press

In accord with the request of Commission 13, the tracks of solar eclipses up to 1963 have been published (75).

Menzel and Redman (76) have published a note on weather data for the eclipse of 20 June 1955. This eclipse is of unusually long duration, and thus particularly useful for studies of faint structures in the outer corona. We have been informed that the Netherlands Eclipse Committee, St Andrews University Observatory, the Cambridge Observatories, London University Observatory, the Royal Observatory of Edinburgh, and the Tokyo Observatory are among those actively considering expeditions. Ceylon appears to be the most popular location, probably because its weather prospects appear somewhat more favourable than those of other possible sites.

The Italian 'Centro di Astrofisica' is now preparing data and maps for the eclipse of 1961, which will be visible in northern Italy; and intends to publish a pamphlet describing the observing conditions at suitable places in the eclipse path. Abetti has suggested that at future eclipses greater attention should be given to the distribution of the various expeditions along the line of totality, to avoid what happened in 1954 at Öland where a large number of expeditions were clouded out.

We call the especial attention of astronomers to the International Geophysical Year, scheduled to cover the period from July 1957 through December 1958. Because of the unusually comprehensive observational coverage to be given to solar and geophysical phenomena during this period,‡ it is hoped that the eclipses of 1958, 19 April and 12 October, will be extensively observed in spite of their relatively inconvenient locations.

Pecker directs the attention of eclipse observers to the annular eclipse of December 1955, which could profitably be utilized not only for studies by radio-astronomers, but also for photospheric studies. Detailed study of the extreme limb of the solar disk, he suggests, would be particularly suitable and important, from the point of view of both the continuous spectrum (with moderate dispersion) and of the line spectrum (large dispersion).

Von Klüber wishes to point out the excellence of the instrument designed by the Astrophysical Observatory of Potsdam for measurement of the Einstein effect, with the hope that it may be used as soon as possible at a future eclipse. (An attempt at Öland was clouded out.) We are informed that a joint expedition from St Andrews Observatory and the Deutsche Akademie der Wissenschaften of Berlin, to use the instrument, is being considered for 1955.

Atkinson writes that he has sent the following suggestions to Clemence and Sadler, regarding the eclipse pages of the Almanacs:

(*a*) The quantities l_1 and l_2 should be adjusted to correspond with the true mean lunar semidiameter, instead of with the fictitious undersized one given by $\sin s = \cdot 272274 \sin \pi$; alternatively, if the present figure is retained, there should be an explicit statement of the way to make the change to the true figure. (This is very simple, but is not generally known.) The true mean must be used whenever one wishes to apply limb-corrections, and this can be desirable nowadays even for the purposes of 'solar physics' eclipse work. (*b*) The Sun's place should be adjusted for the corrections (now pretty well established) to Newcomb's perigee and eccentricity. (A correction to the obliquity is not necessary in eclipses, because it will affect the Moon's tabular place just as much as the Sun's.) The mean longitude correction which has so far been applied is $+1''.0 \pm 0''.06$ roughly; the effect of changing h and k amounts in November to about $+0''.4 \pm 0''.02$ in α, and there seems good reason to include it. (*c*) Librations should be tabulated for the time of mid-eclipse, together with their rates of change and the differential formulae (77) for correction to any place on the earth. (This should be done for the P.A. as well as for l and b.) (*d*) Rough limb-profiles for mid-eclipse should be tabulated, even without waiting for Watt's final results. These would be useful for solar physicists; for geodetic work one needs, of course, the best profiles one can get. It is true that if (*d*) is done (*c*) becomes largely superfluous; (*d*) may, however, be thought impracticable. One can also

‡ See *Science*, **119**, 569, 1954, and *Proc. Nat. Acad. Sci.* **40**, 922, 1954

improve the prediction of eclipses if one allows for the fact that the Tables use the true Equinox, while the eclipse timing is based on FK3 and is also affected by polar variation. Probably there is in principle a correction due to the fact that Brown used the parallax corresponding to the ellipticity 1/294.

Subject to proper application of the above corrections, it should nowadays be possible to go much nearer to the limits of the eclipse track, without risk of finding oneself actually outside, than has been practicable in the past.... If one is near the edge, but not outside, the duration of totality is of course much reduced; but the length of time one is low down in the chromosphere is much increased. The impression one gets from the occultation results is that the Moon's place is still rather uncertain and variable, with no guarantee that the phase of the variation would be the same at age 0^d as it is at age $9^d \pm$; I believe, however, that much of this variation (which is especially noticeable in latitude) is predictable and that its phase at 0^d can be assigned. (We have a paper on this partly worked out.) Even if not, however, the error nowadays should be only a small fraction of a second of arc in both co-ordinates, corresponding to a fraction of a mile on the Earth's surface, and Watts can give limb corrections with this accuracy too.

There appears to be a general agreement in the Almanac Offices that some changes should be made in the eclipse pages. The agreement is perhaps less complete on the nature of the changes needed. Since the Offices are preparing eclipse data several years in advance, at the request of this Commission, 1960 is the earliest year that Atkinson's proposals could be introduced. By this date Watts' final results for the Moon's profile should be available.

We are informed that at the coming meeting of the Commission Clemence intends to present for discussion a summary of changes planned for the eclipse pages, to begin with the 1960 American Ephemeris.

Athay points out the need for further improvements in observations of the flash spectrum in respect to height resolution, wave-length range, and quality of the spectrograms. Good Paschen series observations would be particularly desirable. Moreover, present evidence of chromospheric variability makes it mandatory that the entire spectrum be observed at a single eclipse, since one cannot properly compare, e.g., Paschen series observations from a future eclipse with Balmer series data from a prior eclipse. Further he suggests that optical observations over a wide wave-length range of the chromosphere and coronal spectrum, co-ordinated with and made simultaneously with radio-noise observations at a number of wave-lengths, would be of great value in reconciling the radio and optical models of the solar atmosphere. The optical problem could profitably include slitless-spectrograph observations of the jumping-film type, slit spectra of line-profiles, and high resolution white-light pictures of the chromosphere and corona for showing structural details. The radio-noise programme should include observations to as short a wave-length as possible.

Kiepenheuer suggests the need for a co-ordination of photographic records along the eclipse track to search for evidence of rapid ascending motions in the outer corona. He finds that the existence of such motions can be inferred from the energy balance of geomagnetic storms (78) as well as from the displacements of the sources of radio outbursts, observed with interferometers. We suggest that a search for this important phenomenon might be particularly valuable at the 12 October 1958 eclipse, during the International Geophysical Year when geophysical phenomena will be under intensive observation. Also the level of solar activity should be relatively high, providing better, though probably still small chances of success.

F. Link has suggested that more organization is needed in the publication of the increasingly extensive eclipse results, to make them more readily accessible to everyone interested in the field. He has proposed that, a certain time after the eclipse (e.g. 5 years), the principal results obtained by the various expeditions be published in a single volume organized according to subject-matter. This volume would not be intended as a substitute for the more comprehensive reports which would continue to be published in the various national journals. He suggests that the editing of the proposed volumes be carried out by a special sub-commission of Commission 13, and offers to help with the proposed work.

The President, however, believes this suggestion impractical in the form proposed. As an alternative possibility, he suggests that if symposia were to be held, systematically, on results from a given eclipse, the published proceedings might fulfil the stated need.

I wish to express my thanks to Dr Barbara Bell for her assistance in the preparation of this report.

DONALD H. MENZEL
President of the Commission

REFERENCES

(1) H. von Klüber, *Naturwiss.* **39**, 199, 1952; *Nordisk Astronomisk Tidsskrift*, no. 1, 1953.
(2) H. von Klüber, *Naturwiss.* (in the Press).
(3) G. van Biesbroeck, *Astr. J.* **58**, 87, 1953.
(4) A. A. Mikhailov, *Solar Eclipse of* 30 *June* 1954 *in U.S.S.R.*, Acad. Sci. U.S.S.R., Moscow, 1953.
(5) R. d'E. Atkinson, *M.N.* **113**, 18, 1953.
(6) R. d'E. Atkinson and J. D. Pope, *M.N.* **113**, 635, 1953.
(7) R. d'E. Atkinson and C. A. Murray, to appear in *M.N.*
(8) R. d'E. Atkinson, *M.N.* **113**, 18, 1953.
(9) H. Kristenson, *Arkiv för Astr.* **1**, no. 29, 1954.
(10) J. M. Torroja, *Semin. Astron. Geod. Madrid*, Publ. no. 23, 1954.
(11) F. J. Heyden *et al.*, *Ap. J.* **118**, 412, 1953.
(12) B. Lindblad and H. Kristenson, *Atti del Convegno Volta*, p. 61.
(13) H. Kristenson, *Stockholm Observatory Annals*, **18**, no. 5 (in the Press).
(14) J. Houtgast and C. Zwaan, *Atti del Convegno Volta*, p. 68.
(15) R. G. Athay *et al.*, *Ap. J.* **120**, 94, 1954.
(16) R. G. Athay *et al.*, *Ap. J.* **120**, 94, 1954.
(17) R. G. Athay and R. N. Thomas, *Ap. J.*, suppl. ser. **1**, no. 12, 491, 1955.
(18) S. Matsushima, *Ap. J.*, suppl. ser. **1**, no. 12, 479, 1955.
(19) R. G. Athay, J. W. Evans and W. O. Roberts, *Observatory*, **74**, 244, 1954.
(20) V. P. Vyazanitsyn (in the Press).
(21) V. A. Krat, *Bull. Pulkova Obs.* **19**, no. 152, 1954.
(22) *J.R.A.S. Canada*, **48**, Nov.–Dec. 1954; *Sky and Tel.* **13**, 355, 1954.
(23) *Sky and Tel.* **13**, 354, 1954; *J.R.A.S. Canada*, **48**, 189, 163, 1954.
(24) G. Righini, *Atti del Convegno Volta*, p. 82.
(25) K. Araki, *Publ. Astr. Soc. Japan*, **4**, no. 1, 1952.
(26) R. O. Redman, *Atti del Convegno Volta*, p. 72.
(27) H. A. Brück and D. A. Jackson, *Proc. Roy. Soc.* A, **216**, 183, 1953; *Dunsink Obs. Contr.* no. 7.
(28) H. A. Brück, *Atti del Convegno Volta*, p. 79.
(29) R. G. Athay *et al.*, *Ap. J.*, suppl. ser. **1**, no. 12, 505, 1955.
(30) R. G. Athay and J. C. Pecker, *Ap. J.* **121**, 391, 1955.
(31) S. Matsushima, *Ap. J.* **115**, 544, 1952.
(32) I. Kawaguchi, *Publ. Astr. Soc. Japan*, **3**, 171, 1952.
(33) J. T. Jefferies, *Austral. J. Phys.* **6**, 22, 1953.
(34) J. H. Piddington, *Ap. J.* **119**, 531, 1954.
(35) E. J. Blum *et al.*, *Ann. Ap.* **15**, 184, 1952; *C.R.* **233**, 917, 1951.
(36) E. J. Blum *et al.*, *C.R.* **234**, 1597, 1952.
(37) M. Laffineur *et al.*, *C.R.* **234**, 1528, 1952.
(38) K. Aoki, *Rep. Ionos. Res. Japan*, **7**, 109, 1953.
(39) R. Coutrez, A. Koeckelenbergh and E. Pourbaix, *Observatory*, **73**, 239, 1953.
(40) C. W. Allen, *Rep. Prog. Phys.* **17**, 135, 1954.

(41) B. Lyot and A. Dollfus, *C.R.* **237**, 855, 1953.
(42) A. Danjon, *C.R.*, **237**, 854, 1953.
(43) G. Righini, *Atti del Convegno Volta*, p. 210.
(44) D. Layzer, *M.N.* (in the Press).
(45) H. von Klüber and A. H. Jarrett, *Nature*, **169**, 790, 1952.
(46) K. Saito, *Ann. Tokyo Astron. Obs.* 2nd ser. **3**, 223, 1953.
(47) R. G. Athay and W. O. Roberts, *Ap. J.*, **121**, 231, 1955.
(48) H. von Klüber, *Observatory*, **72**, 207, 1952.
(49) C. W. Allen, *M.N.* **104**, 13, 1944.
(50) R. Müller, *Observatory*, **74**, 222, 1954.
(51) A. Colacevich, *Atti del Convegno Volta*, p. 186.
(52) *The Sun*, ed. G. P. Kuiper (Univ. of Chicago Press), p. 258.
(53) N. N. Sytinskaya and A. K. Suslov, *U.S.S.R. Astr. Circ.* no. 136, 1953.
(54) A. K. Sosnova, *Bull. Stalinabad Obs.* no. 9, 1954.
(55) J. M. Ramberg, *Ann. Stockholm Obs.* **17**, no. 2, 1951; and no. 7, 1953.
(56) J. M. Ramberg, *Ann. Stockholm Obs.* **16**, no. 3, 1951.
(57) M. Waldmeier, *Z. Ap.* **33**, 286, 1954.
(58) M. Cimino, *C.R. Accad. Naz. Lincei*, **15**, 39, 1953.
(59) D. E. Blackwell, *M.N.* **112**, 652, 1952.
(60) V. V. Sharonov, *U.S.S.R. Astron. Circ.* no. 125, 1952.
(61) M. Fracastoro, *Atti del Convegno Volta*, p. 192; and *Mem. Accad. Lincei*, 8th ser., **4**, Rome, 1953.
(62) M. A. Vashakidze and M. G. Kolkhidashvili, *Bull. Abastumani Obs.* no. 17, 1954.
(63) E. J. Bugoslavskaja, *Comm. Sternberg State Astron. Inst.* no. 96, 1954.
(64) E. J. Bugoslavskaja, *The Structure of the Solar Chromosphere*, 1951.
(65) G. M. Nicolsky, *A.J. U.S.S.R.* **30**, 286, 1953.
(66) G. Abetti, *Atti del Convegno Volta*, p. 268.
(67) W. A. Rense, J. M. Jackson and B. Todd, *J. Geophys. Res.* **58**, 369, 1953.
(68) G. van Biesbroeck, *Sky and Tel.* **13**, 377, 1954.
(69) R. O. Redman and H. Zanstra, *Proc. K. Akad. Wet. Amst.* B, **55**, 598, 1952.
(70) S. G. M. Haug, *Proc. K. Akad. Wet. Amst.* B, **55**, 517, 1952.
(71) D. Koelbloed, *Proc. K. Akad. Wet. Amst.* B, **55**, 524, 1952.
(72) G. Thiessen, *Z. Ap.* **30**, 8, 1951.
(73) V. A. Krat, *C.R. Acad. Sci. U.R.S.S.* **91**, 757, 1953.
(74) Y. Nakata, *Ionosphere Res. Japan*, **7**, 157, 1953.
(75) *U.S. Naval Obs. Circ.* nos. 1, 2, 16, 40, 53, 59.
(76) D. H. Menzel and R. O. Redman, *Observatory*, **74**, 138, 1954.
(77) R. d'E. Atkinson, *M.N.* **111**, 448, 1951.
(78) *The Sun*, ed. Kuiper, p. 449.
(79) G. Eriksen, Ø. Hauge, and E. Tandberg Hanssen, *Astrophysica Norvegica*, **5**, no. 4, 1955.

Additions to the Draft Report

Kharadze submitted an item concerning the 1954 eclipse. By radiometric measures of the solar corona, J. Kumsyshvili of Abastumani Observatory found the coronal radiation to be $1\cdot43\times10^{-6}$ of Sun radiation ($1\cdot18\times10^{-6}$ in 1941 according to Nikonov and $5\cdot7\times10^{-6}$ in 1952 according to Seltzer) and colour excess of corona 0·16 magnitudes (0·27 in 1941—Nikonov, and 0·0 in 1952—Seltzer). Rosseland reported that the Institute of Theoretical Astrophysics, Oslo, observed the 1954 eclipse on two frequencies, 200 and 500 Mc./s. (79) The President also recently received reports from Notuki and from von Klüber regarding the 1955 eclipse.

Notuki writes that the group organized by the Tokyo Astronomical Observatory, the Astrophysical Department of Kyoto University, and the Astronomical Department of

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Tohoku University planned to observe the solar chromosphere and corona including the zodiacal light at the eclipse of 20 June 1955, but observations were not obtained because of bad weather.

The Japanese Hydrographic Office observed the eclipse at the eastern shore (Ha-Hap Coast) of the Kikuik Bay in South Viet-Nam with approximate longitude 100° 48′ E. and latitude 15° 25′ N. The observations comprised photo-electric and cinematographic determinations of time of contacts, and photometric photometry of the solar corona. The details of methods and results will be published in the near future.

For the total eclipse of 1955, June 20, H. von Klüber (Cambridge University) and Dr A. H. Jarrett (St Andrews University) had prepared, on a site at Hingurakgoda airfield, Ceylon, an investigation of the green (5303) and of the red (6374) emission lines of the corona by a multicoated Fabry–Perot interferometer combined with a narrow band interference filter and applied some improvements indicated by their first successful attempt with similar equipment at the 1954 eclipse. As the phase of totality was completely overcast, no exposures of the corona could be obtained. But comparison test plates of a mercury isotope emission tube taken before and after the eclipse proved that the interferometer and the filter with their sensitive surface coatings had been in best condition, and that, therefore, even under the rather unfavourable tropical conditions, the applied method would have worked very well.

Von Klüber further writes that the large horizontal camera of the Astrophysical Observatory of Potsdam for testing the light deflection according to Einstein's theory had also been installed by the observers, Mr W. Mattig and Mr E. Strohbusch, at Hingurakgoda and proved by many star exposures during the nights preceding the eclipse to give excellent star images. A coelostat specially designed by C. Zeiss, Jena, of very high guiding performance, electrically synchronized from a clock, and a quartz mirror, were used. Exposures by this instrument during totality were also prevented by clouds.

Report of the meeting. 3 September 1955

PRESIDENT: Prof. Donald H. Menzel.

SECRETARY: Miss Barbara Bell.

The President convened the meeting and outlined the order of business. Mrs Gossner and Rosseland submitted amendments to the Draft Report. Minnaert expressed the appreciation of the Commission to the President for the report and for the attached bibliography. The Draft Report was accepted as amended.

The President mentioned reports on the 1954 eclipse from Kharadze and on the 1955 eclipse received from von Klüber and from Notuki and invited additional reports.

Michard reported that a French expedition had observed the 1955 eclipse from a military airplane at 30,000 ft. over Indo-China. They obtained photometric and polarometric data in the yellow, red and infra-red of the corona at 3 to 20 radii from the solar centre. Cirrus clouds and mechanical difficulty with the wide field camera prevented observation of the gap between the corona and the zodiacal light.

Redman drew attention to Blackwell's observations up to 18° from the Sun as a contribution to closing the gap between corona and zodiacal light.

Hatanaka reported that Japanese radio observations yielded a determination of the brightness distribution at 10 cm. An enhanced region coinciding with a Hα plage was observed.

Waldmeier showed photographs of the 1955 corona secured in the Philippines. He drew attention to the contrast in coronal structure observed in 1954 and 1955 and pointed out that in 1955 the north polar corona was much brighter than the south and in accord with the higher level of general solar activity in the north.

The President then asked Mrs S. D. Gossner to summarize changes planned in the

https://doi.org/10.1017/S0251107X00035562 Published online by Cambridge University Press

eclipse pages of the Almanacs. Mrs Gossner informed the Commission that the U.S. Naval Observatory has published in its *Circular No. 59* the tracks of solar eclipses for 1960 up to 1964, with the exception of the 1963 annular. The latter has now been computed as well and may be obtained from the office of the *American Ephemeris*. All data have been tabulated in terms of Ephemeris Time, and the circular contains specific instructions for the introduction of ΔT.

As a part of the unification as from 1960 of the *American Ephemeris* and (British) *Nautical Almanac*, a revision of the eclipse section of these volumes has been planned. The principal changes will be as follows:

(*a*) The Besselian elements and the central line data will be tabulated in function of Ephemeris Time. In order to facilitate the introduction of ΔT, the angle μ and the longitudes will be referred to the 'Ephemeris meridian' as defined by D. H. Sadler, *Occasional Notes of the R.A.S.* no. 17, vol. **3**, 1954.

(*b*) Wherever practical, the tabular interval for the central lines will be reduced, so that the first difference of two consecutive longitudes shall not exceed 3°.

(*c*) The publication of local circumstances will be discontinued, but it is hoped that the improved form of the map will enable observers to scale off the times of first and fourth contacts to within a minute, without any computation.

(*d*) The maps for all major eclipses will be expanded to cover two facing pages. At the suggestion of D. H. Sadler, the curves of beginning and ending of the eclipse will be replaced by two families of curves giving respectively the time of middle and the semi-duration. These curves are more nearly orthogonal to each other. It will thus be possible to reduce the time interval for which they are given, thereby facilitating their interpolation.

Mrs Gossner assured the Commission, in response to Redman's query, that the new tables would, as always, be accompanied by an explanation for their use.

Atkinson raised the questions (*a*)–(*d*) appearing in the Draft Report. Mrs Gossner replied that (*a*) there is no present plan to include corrections to the true mean lunar semi-diameter, but that the correction can easily be calculated by those who need it; (*b*) uncertainty in extrapolation of ΔT places a limit on the possible accuracy of eclipse predictions; (*c*) the amount of work involved makes it impractical to incorporate all the details of the limb correction, most of which would never be used; limb corrections should rather be computed only for the reduction of actual observations.

O'Keefe pointed out that the inexact surveying available in most parts of the world makes it hopeless in principle to determine the exact instant of contact. Minnaert also commented on the difficulty caused by the irregularities of the lunar limb, and Atkinson pointed out that this was being reduced by the work of Watts.

Wolbach asked whether there was any indication for variation in the level of the photosphere. Öhman commented that Munich has started a programme for accurate determination of the solar diameter which may yield an answer to this question.

The President thanked Mrs Gossner for her description of the improvements introduced in the eclipse pages and suggested that the Commission next take up questions concerning specific future eclipses.

Righini discussed the eclipse of 1961 in Italy and distributed to interested members of the Commission a table of climatological data prepared at the Observatory of Brera, and elements of the eclipse in Italy computed by F. Zagar. He noted that the Arcetri Observatory lies two miles north of the central line where the eclipse would occur at 7.30 U.T. at 12° elevation and a duration of 130 sec. The probability of a clear sky was estimated as 30–35% at Florence and somewhat better at San Remo.

The President noted that the 1961 eclipse also passes over the Simeis Observatory. Mustel said that the Crimean Observatory had also only about a 30% probability for a clear sky.

Houtgast emphasized the desirability of more reports such as that presented by Righini, for other places and other eclipses.

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The President presented some suggestions from a letter by von Klüber for consideration by the members: (1) von Klüber suggested that, in view of the growing number of eclipse expeditions, it might be worth while for an astronomer experienced both in travelling and in eclipse expeditions to visit the more promising regions in the totality belt 1–2 years prior to the eclipse to collect information desired by the various eclipse teams—information concerning weather, accommodations and other facilities. He suggested this might well be sponsored by Commission 13. (2) Von Klüber also warned of the need to distinguish, especially for the eclipse of 1959, between 'good weather' and good astronomical visibility; the latter may be poor at ground level at desert sites, because of fine sand and dust, even when clear skies appear assured. (3) The President also noted that von Klüber has prepared a summary of information relating to islands in the Pacific from which the eclipse of 12 October 1958 should be visible.

A general discussion of the problem of weather and eclipses followed. Atkinson noted that cloudiness tabulations were inadequate to distinguish between 50% chance of total overcast and 100% chance of broken clouds. Minnaert cautioned against placing much weight on weather observations made by reconnoitring astronomers, and advised consultation with meteorologists who have lived an extended period in the relevant vicinity as an aid to interpreting long-term statistics. O'Keefe recommended consideration of local irregularities in the statistical weather pattern, particularly in the vicinity of mountains, and suggested that a study of the distribution of vegetation might give useful information about precipitation. Redman cited the cirrus clouds at Khartoum as an example of how misleading meteorological statistics can be. Athay emphasized the need for study of local conditions, and for attention to the distinction between astronomical clarity and meteorological clarity. Wolbach suggested that aerial photography might profitably be used to study the movements of clouds over local features.

Redman raised the question of financial support for a reconnoitring astronomer. The President said, and others appeared to agree, that the financial problem would make it impractical, at present, for Commission 13 to sponsor a reconnoitring astronomer.

Michard and the President stressed the need for enlisting the aid of local astronomers and also other scientists in studying the weather for eclipse purposes. Righini stated that he planned to organize amateurs along the 1961 eclipse path for this purpose.

Atkinson said that it would be desirable for meteorological offices to measure sky blueness as well as percentage cloudiness. Evans said that Sacramento Peak has several instruments designed to measure the brightness of the sky near the Sun and could probably arrange to lend one for observations at eclipse sites. Minnaert suggested that amateurs compare the sky with standard shades of blue paper.

Redman brought up the 1958 eclipse, noting that the principal weather data, wartime observations by the U.S. Air Force, were not available. Hagen said useful information could be found in *Climatic Charts of the Oceans* and Mrs Gossner mentioned the U.S. Hydrographic Office Sailing Directions as a source of data. Mulders volunteered to see if the Air Force data could be made available to astronomers.

The President suggested that, because of the amount of work involved, collection of weather data should be the responsibility of a different astronomer or group of astronomers for each eclipse. The President invited a proposal.

Thomas proposed that the President be empowered to appoint, for each eclipse up to 1962, a chairman of a weather committee, and such other members as may be mutually agreed on, the duty of the committee being to collect weather data and other relevant facts not included in the ordinary meteorological report, and to disseminate this information to interested astronomers.

The motion was approved by the members. The President appointed Righini as chairman for the 1961 eclipse, and Mulders for 1958. Michard volunteered to be a member of the committee for 1959.

Mrs Gossner and Hatanaka raised the problem of access to the Pacific atolls for the 1958 eclipse. Mulders offered to provide liaison between 1958 eclipse expedition and the U.S. Navy. Mulders not being a member of the Commission, the President and members of the Commission expressed a desire that he be co-opted as a member. In reply to a query from Hagen, seven astronomers expressed hopes for observing the 1958 eclipse and the President estimated there might be as many as 15–20 eclipse expeditions. Because of the International Geophysical Year, numerous geophysicists might also be expected to collaborate with the Navy, Mulders noted.

The President directed the discussion to scientific phases of future eclipses.

Thomas reported that (1) optical and radio reductions of the 1952 eclipse results are now in good agreement; (2) present material provides strong evidence for variation in the logarithmic emission-height gradient, with indications of a higher emission gradient at spot maximum than at spot minimum. He noted the scarcity of observation close to maximum and accordingly stressed the importance of the 1958 and 1959 eclipses for data on chromospheric variability; (3) Thomas also called attention to the discordant emission gradients resulting from eclipse, filter and spectroheliograph observations in Hα, the non-eclipse results giving flatter gradients than observations during eclipses. He emphasized the need for high-altitude observations of the chromosphere such as those being made by Dunn at Sacramento Peak.

Öhman pointed out the need for data on chromosphere near the solar poles which tend to be neglected; classical work has shown variations in the height of the chromosphere at the poles relative to the equator. Goldberg mentioned that Mohler's studies of He, λ 10830, revealed the intensity near the equator to be about twice that at the poles.

Atkinson pointed out that sites near the edge of totality provide a longer time for study of the low chromosphere. The President said that such sites would be useful, also, for direct photographs of chromospheric spicules.

Athay recommended use of an image divider so that proper exposures will be possible of both strong and weak spectral lines. He called attention to the importance of observing (1) coronal lines in the upper chromosphere, (2) the rise to maximum intensity of the H and He lines in the region of transition between the chromosphere and photosphere.

The President inquired whether there were any resolutions to be submitted to the Executive Committee. No resolutions were offered and the President adjourned the meeting.

Immediately following the meeting, the President of Commission 13, in consultation with the Presidents of Commissions 11 and 12, appointed an unofficial committee to co-ordinate studies of the physical structure of the solar atmosphere by means of eclipses, radio, and coronagraphic technics. The primary objective is the bringing together of observational and analytical investigations. Chairman: John P. Hagen. Secretaries: C. de Jager, J. C. Pecker and R. N. Thomas.