13. COMMISSION DES ECLIPSES DU SOLEIL

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Very few new observations have been made in the period since the last Report. A large number of astronomers went to Ceylon for the total solar eclipse of 1955 June 20, where no observations were possible because of cloud. At recent eclipses parties of observers have tended to cluster together tightly near the spot with the most favourable weather prediction, neglecting other sites with an only slightly inferior weather record. The disadvantages of such a policy have been shown clearly both in Ceylon and, a year earlier, in Öland, Sweden. In 1955 only a few observers in Viet Nam obtained any results.

The total eclipse of 1956 June 8 over the south Pacific Ocean was not observed, as far as is known. The eclipse of 1957 October 23, a non-central eclipse in which the axis of the shadow cone did not quite meet the Earth's surface, was total in Antarctica. It was observed just outside the totality zone, from the Royal Society Base at Halley Bay, where the corona could be seen at the maximum phase. No optical work was attempted. A special programme of ionospheric observations was planned by I.G.Y. observers at Halley Bay. The results are not yet available.

Most of the following Report is devoted to work arising from older eclipses, mainly those of 1952 and 1954.

PROGRESS OF RESEARCH

Geodetic and related work

The accurate timing of eclipses in order to measure the Moon's position seems to be no longer worth while, in view of the introduction of the Markowitz Moon-camera, which promises to provide far more and far better data than can be obtained from eclipses. There is perhaps still a case in principle for using eclipses to deduce geodetic information, but if really valuable results are to be obtained it is necessary to obtain measurements from a number of observers well spread out along the eclipse track. Fairly elaborate organization is needed, as well as good fortune and good weather. Results are seriously affected by lunar limb irregularities [1, 2].

Mrs Gossner [3] has shown that if the time of maximum obscuration at an eclipse is to be computed to 0·01 sec the hitherto neglected slow variation of radius of the penumbra and umbra must be taken into account.

Extreme limb

Workers at the Arcetri Observatory have determined the darkening law very near the limb at the partial eclipse of 1954 June 30 using in one case filters, in the other spectrograms [4, 5]. Hubenet and de Jager [6] have rediscussed 1952 eclipse measurements made by Heyden *et al.* of the integrated brightness, in various colours, of the solar crescent just before second contact and just after third contact. The results tend to support Pagel's model for the upper photosphere. The authors make very useful recommendations with regard to the particular measurements and the accuracy needed for this purpose. Observations should be made on an absolute intensity scale, the error of absolute calibration being not more than 5 %. No more than 5 sec of time at each contact need be covered, the most important measurements being those within 1 sec of contact. At least six observations should be made per second and the mean relative error should not exceed 1 %. Spectrum regions should be chosen to avoid strong chromospheric emission lines.

https://doi.org/10.1017/S0251107X00020800 Published online by Cambridge University Press

Eclipse observers would be greatly helped if all theorists could specify their needs as precisely as this!

A rapid succession of fairly high resolution slit spectra, photographed near second or third contact in such a way as to integrate over the visible photosphere and the lower chromosphere, would be of considerable assistance in studying the transition from Fraunhofer to emission lines. The desired photometric results should be reduced by a differencing process. It is understood that this will form part of the programme of the High Altitude Observatory's expedition to the 1958 eclipse.

Chromosphere

A first instalment of the results obtained by Houtgast at the 1952 February 25 eclipse in Khartoum has appeared [7]. The conventional method was followed, i.e. spectra were photographed at frequent intervals near second and third contacts with a prismatic camera (two prisms, camera focal length 2·6 m, $f/17$, 8 Å/mm at $H\gamma$). The work is particularly valuable because of the care devoted to photometric calibration, including an absolute calibration by photographing sunlight diffused from a magnesium oxide surface on days before and after the eclipse, the Sun being at the same zenith distance as for totality. The work was helped by the favourable Khartoum climate. Absolute intensities are given for about 130 lines in the region 3770 to 4900 Å, in the customary units, namely, ergs sec^{-1} $ster^{-1}$ from a 1 cm wide slice of the chromosphere visible above the Moon's limb. Comparison with earlier results of Pannekoek and Minnaert, and of Cillié and Menzel, suggests that corrections of about 300 km in the zero of the height scale may be necessary (about 0·4 sec of arc on the Sun).

There are appreciable self-absorption effects in the stronger lines (log $I >$ about 12·5). If these effects are avoided as far as possible the intensity gradients with height for Fe I, Fe II and Ti II appear to be all nearly equal. Helium results agree satisfactorily with those obtained by the High Altitude Observatory's expedition, which was also at Khartoum. The helium gradients are much lower than those of the metals. Owing to the great strength of the lines the measures for hydrogen are less accurate, but again there is satisfactory agreement with the High Altitude Observatory's results. This valuable photometric material is to be discussed further in later papers.

A systematic extension of the Utrecht work is being planned. Good spectrograms were obtained at Götland at the 1954 eclipse, chiefly for strong lines, and an expedition to the Canaries is to be undertaken for the 1959 eclipse, chiefly for weak lines in the ultra-violet.

Similar work was carried out by V. P. Vyazanitsyn [8] at the 1952 eclipse, also with an objective prism spectrograph, using lines over a wide range, from 3685 to 6563 Å. He has incorporated 1941 and 1945 eclipse data with his results, which deal with density gradients, electron densities, excitation temperatures and atomic abundances. The intensities of many weak lines in the flash spectrum and also intensity gradients, have been found by R. Bolokadze [9].

V. A. Krat [10] has constructed a new type of spectrograph for the chromosphere, with an $f/2{\cdot}5$ meniscus telescope and an objective diffraction grating. He has measured lines between 3695 and 4861 Å, mainly with the Moon's limb at a height 500 km. The intensity gradients found by him for eight lines are, except for $H\beta$ and K, smaller than those of other observers.

Imperfect photometric calibrations are all too frequent a feature of eclipse photographs, whether of the chromospheric spectrum or corona. Observers commonly underestimate both the amount of care needed in preparation and the chances of something going wrong when working what is essentially laboratory apparatus in field conditions. The precaution of making calibrations for photographic photometry in duplicate or triplicate, troublesome though it may be at an eclipse camp, has more than once proved a rewarding policy. There is no complete substitute for properly carried out calibrations, but the cautious observer is always glad of a second line of defence against misfortune. Athay has suggested that in the case of slitless spectrograms of the chromosphere the continuous spectrum of the corona can often be used as a photometric standard. His method has been applied by Athay, Menzel and Orrall [11] to 1932, 1936 and 1952 flash spectra. They find a reduction of the apparent differences between eclipse and eclipse, e.g. of emission gradients, and attribute this to a reduction of photometric errors. There appears now to be no significant change, over these years, of the Balmer decrement, or of the relative intensities of helium, hydrogen and metal lines. There may be a change in the ratio of line strengths to continuum, but what is found may still be due to residual photometric errors.

Athay writes 'I should like to propose that Commission 13 of the I.A.U. recommend to all eclipse observers at future eclipses that they use the corona as a *secondary* standard. With slitless spectrographs the observers need only take one or more long exposures during totality, in addition to the normal exposures of the flash-spectrum. With slit spectrographs I would recommend that one or more exposures be taken with a radial slit set at right angles to the line of contacts'.

Although the existence has been recognized for many years of local 'active regions' in the chromosphere, where conditions of excitation, etc. are higher than normal, the paper just quoted makes clear how uncertain our knowledge still is of more general variability in the chromospheric spectrum. Possibly sufficient observations to clarify this point could be made in favourable circumstances outside eclipses. There appears, however, still to be a case for a really thorough spectrophotometry of the chromosphere at a few total eclipses, preferably near sunspot maximum and again near sunspot minimum, with apparatus, procedure and observer if possible kept unchanged throughout.

D. V. Thomas [12] has determined the chromospheric temperature from the rotational intensity distribution in the (0–0) band of CN near 3883 Å, using high dispersion slit spectrograms obtained by Redman at the 1952 eclipse. Despite the high resolution the lines are often seriously affected by blending, and self-absorption is important, particularly near the band heads. The excitation temperature is about 4500° K at about 400 km height.

A considerable number of theoretical papers on the chromosphere have been published, based mainly, although not entirely, on the results of pre-war Harvard expeditions (1932 and 1935) and of the 1952 High Altitude Observatory expedition [13-18]. The general trend in these papers is to recognize the importance of deviations from thermodynamical equilibrium, the presence of considerable self-absorption effects in all the stronger spectrum lines at low heights in the chromosphere, and the fact that 'turbulence' is small at the base of the chromosphere, but increases with height. 'Temperatures' vary according to whether they are kinetic temperatures, excitation temperatures, etc., but in the lower chromosphere they are as low as, or lower than, the ordinary photospheric temperature. There is, however, also a growing belief that the chromosphere consists of at least two components having substantially different temperatures, at least above a height of 500 km. The proportion of one component to the other varies with height; their temperatures may vary too. Attempts have been made to relate this structure in some way to the spicules, hitherto studied mainly in $H\alpha$ light and on the uneclipsed Sun. There has been some uncertainty as to whether the spicules are hotter or cooler than the inter-spicule region; Woltjer favours hotter spicules, most other investigators have taken cooler spicules in a hotter medium. Hagen's 1954 radio observations at 8·5 mm were interpreted by him as due to cool spicules in a hotter medium [19].

In general, theoretical discussion of the chromosphere is more the business of Commission 11 than of Commission 13, especially since now the technique of chromospheric observations at high altitude stations outside eclipses is being constantly improved. However, members of Commission 13 need to ask themselves what eclipse observations would contribute most significantly to the elucidation of these newer ideas. It would appear reasonable, too, to expect theoretical workers to suggest measurements which might permit us to discriminate between one theory and another, remembering that at an eclipse one has the advantages of a fairly dark sky, but in other respects is working under difficulties (field conditions, doubtful weather and seeing, very limited time).

Not very much is known of spicule structure in radiation other than Hα. Its examination in the light of the K line, or in other lines in the violet and ultra-violet, may need an eclipse sky. Unfortunately resolution of the finer structure also needs very good seeing, which cannot be guaranteed at an eclipse. The problem of increase of 'turbulence' with height requires accurate spectrum line profiles, especially for heights exceeding 1000 km, and going as high as possible. The transitions from photosphere to chromosphere and from chromosphere to corona need to be studied in more detail [20]. There may be plateaus in the temperature/height relation, associated with the ionization of hydrogen and of helium, which need more investigation. In the very low chromosphere a self-reversal (not merely a self-absorption) of strong lines is observed, which does not appear to be due simply to false photospheric light, and which has not yet been clearly explained. Practically all eclipse studies of the chromospheric spectrum so far have been restricted to regions near the Sun's equator; more high quality measurements are needed near the Sun's poles. Where slit spectrograms are used some better method of determining the height to which they refer is urgently required. (The High Altitude Observatory's plans for the 1958 eclipse are aimed particularly at this problem.)

Prominences

Comparatively little advantage has been taken of eclipses for the study of prominences, especially of their spectra in the violet and ultra-violet. Athay and Orrall [21] have combined measures of the line spectrum of a prominence observed by the High Altitude Observatory's expedition at the 1952 eclipse with measures by Redman and Zanstra of the continuous spectrum of the same prominence. They conclude that the optical thickness of the prominence in Hα was near unity, that none of the hydrogen or helium line intensities was seriously affected by self-absorption, that there were fairly large departures from thermodynamical equilibrium, and that the electron temperature was about 20 000° K. The paper serves to draw attention to prominence problems which should be more often tackled at eclipses. A wider and more precise comparison of chromospheric and prominence spectra would be of considerable interest.

V. N. Zuikov [22] has used slitless spectrograms, also from the 1952 eclipse, to measure equivalent widths of twelve lines of H, He, and Ca II in a number of prominences. From these data he calculated the densities of hydrogen (second state), calcium, and electrons, and excitation temperatures for hydrogen and helium.

Photometry of inner corona

As usual there have been a great number of papers on coronal photometry to a few radii from the Sun's centre in more or less white light [23-39], in various spectrum regions [40-49], in the light of the green 5303 Å line [50], and in polarized light [51-54]. Photometric procedures in general seem to be improving and some investigations have been made with great care and thoroughness. There has been a commendable attempt in some cases to put the measures on an absolute basis, by referring them to the brightness of the uneclipsed Sun.

According to Bugoslavskaja, Alieva and Gindilis [34-36] the integrated brightness of the corona at the 1952 February eclipse was $1{\cdot}09 \times 10^{-6}$ of the Sun. Radiometric (thermocouple) measurements by Zeltzer [40] of the same corona gave $5{\cdot}7 \times 10^{-6}$. For the 1954 June eclipse the total corona brightness was $7{\cdot}0 \times 10^{-7}$ for visual measures (Sharonov) [42], $7{\cdot}05 \times 10^{-7}$ for yellow light (Leningrad University expedition) [44], $6{\cdot}14 \times 10^{-7}$ in photographic light (Sytinskaya) [43] and $6{\cdot}02 \times 10^{-7}$ in the blue (Leningrad University expedition). Radiometric measurements by Kumsishvili [45] gave $1{\cdot}43 \times 10^{-6}$.

While there is always room for precise measurements on an accurate absolute scale, it is questionable whether there is much further need for purely relative photometry of the corona within 3 or 4 radii of the Sun's centre, of the kind commonly made for very many years past, in no special spectrum region and not always with a satisfactory plate calibration. If observers wish to do work of this kind they should be encouraged to concentrate on monochromatic photometry, e.g. in the light of the 5303 Å line, or on polarization measures where there is some hope of separating K and F coronas and thus finding a significant physical interpretation of the results, or on studying detailed structure, e.g. the arches over prominences, the polar plumes, etc. (on fairly large-scale photographs of good quality).

P. N. Polupan [50] has constructed isophotal contours for 5303 Å radiation, from a spectrogram taken at the 1952 eclipse with a 5 m prismatic camera. The maximum intensity was at about 30″ from the limb.

H. von Klüber [52] has completed a very thorough photometry of the 1952 corona in polarized light, using Fesenkov's method of photographing simultaneously in three planes of polarization. The measures, which cover the whole corona to $3{\cdot}5R_{\odot}$, have been compared with the van de Hulst model. Except for a fairly small deviation in a conspicuous coronal ray the plane of polarization was radial to the Sun. A very similar investigation by Fesenkov's method was carried out also by M. A. Vashakidze [53] at the 1952 eclipse. He finds that the corona polarization is in general radial, as expected, and that his measures agree fairly well with the van de Hulst model. He mentions the need for more detailed measures on large scale photographs, in the neighbourhood of irregularities such as rays or arches.

Such work must have a very good sky to be completely successful. Similar measures by Blaha and Svestka [54] at the 1954 eclipse, made through a thin layer of cirrostratus cloud, showed strong deviations from radially symmetrical polarization, ascribed for the most part to the effect of scattering in the cloud. It should be noted that quite apart from complications due to cloud the sky background during totality is normally rather strongly polarized and that if accurate results are desired this sky polarization (which is likely to vary considerably during totality) must be measured and allowed for.

Observers dealing with work of this character are urged always to give orientation marks on any photographs or drawings of the corona which they may publish. They should also make it very clear whether they measure distances in the corona from the limb or from the Sun's centre.

Spectrum of corona

If we are to understand the structure of the corona, to check the accuracy of polarization methods for separating dust corona from electron corona, to find the temperature distribution, etc., spectroscopic observations are essential. Useful information may be obtained from slitless spectra, but for most purposes either a slit spectrograph or an interferometer is essential.

Jarrett and von Klüber have published their 1954 interferometer measures of the width of the green 5303 Å line [55]. In spite of thin cloud, line widths could be measured between $1{\cdot}03$ and $1{\cdot}3R_{\odot}$. The resolving power was about 20 000. If the widths are interpreted in terms of kinetic temperatures, T varied between $2{\cdot}2$ and 5×10^{6} °K, with most values near $2{\cdot}5\times10^{6}$. The work demonstrated conclusively the practicability of this method, so often tried without success in the past. In favourable sky conditions more extensive and elaborate measurements should be possible.

Allen [56], using a fast spectrograph (240 Å/mm at Hγ), with an occulting bar in the optical train to reduce the great difference of brightness between inner and outer corona, succeeded in obtaining coronal spectra at the 1954 eclipse out to $6R_{\odot}$. The photographs were taken through thin cloud. Some difficulty was encountered with the optical performance of the spectrograph camera, but the spectral intensity distribution could be measured as a function of radial distance from the Sun, and an attempt was also made to measure Fraunhofer line intensities. The results suggest a higher ratio of electron to dust coronas than in the van de Hulst model. There is a great need for more measures of this kind.

Also at the 1954 eclipse, and in good sky conditions, Minnaert [57] used a multiple slit spectrograph (dispersion 35 Å/mm near H and K) for various parts of the corona within about $2R_{\odot}$ and obtained successful photographs with exposure times between 4 and 70 sec. In the continuous spectrum of the inner corona there is a shallow depression corresponding to groups of Fraunhofer lines beyond H and K. It has not been possible to ascertain whether this depression is wider than in the normal Fraunhofer spectrum. The full results of this work are not yet available.

N. N. Parijsky and K. I. Petrova [58] measured the absolute intensities of the [Ni XII] 4231 Å, [Fe XIV] 5303 Å and [Fe X] 6374 Å emission lines at the 1952 eclipse at various distances from the limb, in four different active regions, using a slit spectrograph with a Schmidt camera (focal length 200 mm, $f/2$). The green line intensity varied from 10 erg sec^{-1} cm^{-2} ster^{-1} at 3′ from the limb to 0·2 at 12′, and in different regions at the same distance from the limb it varied by a factor 10. In one region the 5303/4231 ratio ranged between 10 and 20. A considerable diffusion of strong chromospheric H and He lines by the terrestrial atmosphere was noted. N. N. Parijsky and N. B. Grigorjeva [59] have more recently measured the equivalent widths of 120 lines in the spectra of the corona, the higher chromosphere and prominences. Equivalent widths and relative intensities of several coronal lines have been determined by N. V. Shcheglov [60]. Wavelengths of known emission lines and of a number of new lines have been measured by M. K. Aly [61] on spectrograms obtained by B. Lyot and himself at the 1952 eclipse. Two spectrographs were used, designed by Lyot, one with glass optics giving 11 Å/mm in the violet, the other with quartz optics giving 25 Å/mm. The slits were circular and intended to lie about 1′ outside the image of the Sun's limb, with a double-image device whereby spectra from opposite sides of the Sun could be photographed simultaneously, but nevertheless appear separately below each other on the plate. Several exposures, from 1 to 90 sec duration, were made with each spectrograph. The spectrograms between them covered the whole range from 3100 to 6900 Å.

V. A. Fedoretz [62], using plates obtained at the 1952 eclipse, found that the distribution of energy in the coronal spectrum does not differ from that of the Sun.

While polarization and spectrophotometric measures are likely to remain the chief means of distinguishing between K and F coronas, attention may be drawn to independent attempts, by A. Dollfus and by W. Unno and K. Takakuto respectively, to photograph the corona at the 1955 eclipse through a bi-refringent filter having a narrow pass-band centred on a strong Fraunhofer line, which would reduce the F corona very considerably relative to the K corona. No results were obtained, owing to clouds.

Structure of the inner corona

There is a widespread belief that a great deal of the structure of the inner corona is controlled by magnetic fields, although we know very little of the field-strength or of the precise mechanism by which the rays and polar plumes are formed. The polar plumes have been shown by several authors (e.g. Nikolsky [63], Waldmeier [64]) to deviate appreciably from the lines of force of a hypothetical dipole at the Sun's centre.

E. J. Bugoslavskaja [65] has examined the structure of the inner corona as it varies between sunspot maximum and minimum. A number of authors have expressed slight surprise at the elongation and symmetry of the corona of 1954 June 30, which was a time of unusually low solar activity. Gold [66] suggests that the corona would naturally settle down to this shape in the absence of erratic disturbances such as arise when sunspots are more abundant. He also draws attention to the significance of the observed high degree of symmetry about the solar equator, which persisted at least to $5R_{\odot}$. In work mentioned in the next section Blackwell found a remarkable symmetry (in 1955) of the zodiacal light about the ecliptic. There is good reason to regard the outermost corona as continuous with the interplanetary material which gives rise to the zodiacal light, and Blackwell has pointed out the importance of trying to discover where and how the symmetry about the solar equator changes to symmetry about the plane of the ecliptic.

Outer corona

Any optical study of the outer corona encounters formidable difficulties, partly owing to the glare of the relatively bright inner corona, but chiefly owing to the brightness of the sky.

https://doi.org/10.1017/S0251107X00020800 Published online by Cambridge University Press

To reduce photometric difficulties and also to cut down the effect of false light arising in the apparatus, Allen [67] in 1954 used an occulting disk about six focal lengths in front of each of two cameras. Despite thin cloud he was able to get measures to $12R_\odot$ although because of the poor sky 'photometric results cannot be as accurate as was hoped'. The results agree fairly well with van de Hulst's model.

At the same eclipse Blackwell [68, 69], observing from the open door of an aeroplane flying at 30 000 ft, photographed the corona in red light with a multiple camera, some of the photographs being taken through polaroid. He was able to measure the brightness of the corona to $55R_\odot$ and the polarization to $20R_\odot$. A year later, in June 1955, he attempted to photograph the outer corona, again from an aircraft, with the eclipsed Sun below the horizon, after sunset [70]. Owing to bad weather the attempt was not successful, but on other days he photographed the zodiacal light from a height of about 9000 ft in very good conditions. The results of the 1954 and 1955 work together have very much reduced the hitherto wide gap between measures of the outer corona and of the zodiacal light respectively. The measures can be fitted to a smooth run of electron density out to nearly 200 $R_\odot$. The K and F components were separated by means of polarization measurements, but there are still quite serious uncertainties in this method because of our ignorance of the polarization of the F corona, particularly at the larger elongations. These ambiguities may be resolved when better spectroscopic observations are available, both for outer corona and for the zodiacal light.

Michard and Trellis [71] in 1955 photographed the corona in three colours from an aircraft at a height 8000 m over Viet Nam. They were unfortunate in being unable to avoid high thin cloud. The brightness of the corona was measured to $25R_\odot$ and the polarization to $15R_\odot$. As Blackwell [11] has pointed out the only reasonably certain way of getting satisfactory measures, especially of polarization, out to distances greater than $20R_\odot$ is to fly at heights above 10 000 m. He estimates that one should go to 20 000 m to measure polarization to about $40R_\odot$. One must remember that there is not merely a relatively bright sky background; the sky light is also strongly polarized.

N. N. Parijsky [72] has constructed a special nebular spectrograph (1000 Å/mm, $f/0{\cdot}7$) for observations of the outer corona, the zodiacal light and the Gegenschein.

Radio observations

Radio measurements may be made at an eclipse for two distinct purposes, either to find the distribution and behaviour of radio emission from the Sun itself, or to study the behaviour of the terrestrial ionosphere as ionizing radiation, etc. is cut off by the Moon.

If we are studying the solar radio noise the practical problem depends greatly on the wave-length used and on whether the Sun is quiet or active. For 1952 and 1955 eclipses the Sun was moderately quiet and for the 1954 eclipse solar activity was at an exceptionally low level. With a quiet sun, radiation at metre wave-lengths comes to us from the general body of the corona, and whether the optical eclipse happens to be total or not the radio eclipse is only partial. In these circumstances the intensity variation during eclipse does not give much information concerning the distribution of radio brightness over the corona. But at wave-lengths near 1 cm the quiet radiation comes from the chromosphere and the radio eclipse may be total, or nearly total. Measures of the intensity variation during eclipse may then permit the observer to deduce a fairly accurate brightness distribution over the disk.

The problem changes if there is a considerable amount of solar activity. Radio noise then often comes from particular centres and an eclipse may be of assistance in localizing these. However, in all radio problems dealing with the Sun techniques have improved so much in recent years, especially by the use of interferometers, that there is relatively little need to seek eclipse conditions for making measurements.

American, Dutch, French, Japanese [73] and Russian teams [74-77] have reported measurements of the intensity variation in various wave-lengths at the 1952, 1954 and 1956 (partial) eclipses. In metre wave-lengths the radio sun was found to be considerably larger than the optical sun, the size increasing with wave-length, and also varying with time, being less in 1954 than in 1952. Some evidence was found in 1952 to show that there may be rapid variations over the disk in these wave-lengths.

At cm wave-lengths both American and Russian teams report a brightening to the limb, which Hagen has interpreted in terms of a two-component chromosphere of cool, relatively dense, spicules extending into a hotter and less dense medium. Russian observers claim to have detected radio radiation from prominences. At the partial eclipse of 1956 December 2, at wave-length 3 cm D. V. Korolkov and N. S. Soboleva [76] found a powerful source of polarized emission ($T = 400\,000°$, polarization $> 30\,\%$) which they associated with a group of sunspots.

The ionospheric effects of solar eclipses were discussed at length at the 1955 Conference on Solar Eclipses and the Ionosphere [73]. The subject lies outside the ordinary field of interest of the I.A.U. and it will not be considered further here.

Einstein deflexion

A critical discussion of the results of measurement of the Einstein deflexion at six eclipses from 1919 to 1952 has been given by Mikhailov [78]. He emphasizes the great importance of a good scale determination and makes clear that, although we can be sure that the observed shift is of the same order as that predicted by theory, there is still an uncertainty of the order of 10 % in its value. Among the numerous exacting requirements of this work one might mention good seeing (to get maximum contrast between star images and the heavy background of corona) and a fairly rich star field.

FUTURE ECLIPSES

Predictions

Predicted times, geographical co-ordinates of centre lines, durations, etc. for eclipses down to 1963 July 20 have been published by Mrs Gossner [79]. She has also computed the local circumstances of the total eclipse of 1959 October 2, for that part of the path lying within the United States [80]. She has programmed the calculation of future eclipses for an I.B.M. 650 electronic computer and with this has completed the calculations for all solar eclipses to the end of 1971, including not only the usual data but also the circumstances for heights 100, 200 and 300 km in the ionosphere. Much of this material will appear in the U.S. Naval Observatory Circulars, probably before the 1958 General Assembly. It should be noted that from the beginning of 1960 the data are tabulated against Ephemeris Time.

Coming total eclipses

Date	Max. duration (min.)	Where visible
1958 October 12	5·3	Pacific Ocean
1959 October 2	3·0	New England (near sunrise), Canaries, Rio de Oro, Sahara, Ethiopia
1961 February 15	2·8	South France (near sunrise), North Italy, Balkans, Crimea, Urals
1962 February 4	4·1	New Guinea, Solomon Is., Palmyra I.
1963 July 20	1·7	Alaska, North Canada, Quebec, New England

Coming annular eclipses

Date	Max. duration (min.)	Where visible
1959 April 8	7·4	Australia
1961 August 11	6·6	South Atlantic
1962 July 31	3·5	South America, West and Central Africa

Meteorological and other local information

1958 October 12 — Information concerning a number of Pacific islands has been collected by H. von Klüber and circulated in typescript to Commission members and others.

1959 October 2 — Meteorological and other information has been published for the Canary Islands and the Rio de Oro by J. M. Torroja [81]. More detailed information relating to possible observing sites in this region has been collected by H. von Klüber and circulated to Commission members in typescript. A few copies are still available.

1961 February 15 — Local circumstances for the region of north Italy have been published [82] and a summary of meteorological data [83].

R. O. REDMAN
President of the Commission

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COMMISSION 13

Report of Meeting. 16 August 1958

PRESIDENT: R. O. Redman.

SECRETARY: J. Houtgast.

Draft Report. The *Draft Report* was adopted without amendment.

Conversion of Commission 13 *to Sub-Commission* 12*a*. The President reported that at the special meeting of 14 August, held to discuss the Greenstein-Unsöld memorandum, it was proposed for consideration by the Executive Committee that Commission 13 should become Sub-Commission 12*a*.

Future eclipses. Further copies of Dr von Klüber's circular describing local conditions for the eclipse of 1959 October 2 are obtainable from the Cambridge Observatories. A circular has recently been sent out giving meteorological data for the eclipse of 1961 February 15, visible from Italy to the Urals, and for the eclipse of 1962 February 4–5, visible over the western Pacific and the Solomon Islands. No data have been collected yet for the eclipse of 1963 July 20, visible across Alaska, Canada and eastern U.S.A. A short list of possible observing sites for the eclipse of 1965 May 30, visible over the Pacific Ocean, has also been circulated.

Mrs Gossner drew attention to the importance for geodetic work of the eclipse of 1963. She remarked that useful information for the eclipse of 1965 could be found in the Hydrographic Office Sailing Directions for Pacific Islands, or in the British Admiralty Pilot Books.

The President invited Dr Houtgast to talk on 'Some eclipse observations of the low chromosphere'.

The wings of the Balmer lines $H\beta$, $H\gamma$, $H\delta$, and of the Ca^+ lines H and K were measured on spectrograms taken at Khartoum in 1952. The decrease of intensity with increasing distance from the line centre is in accordance with Stark effect and collision damping. The intensity gradient with height in the chromosphere has an unexpectedly low value, being $1{\cdot}5 \times 10^{-8}$ cm^{-1} for the Balmer lines and $2{\cdot}5 \times 10^{-8}$ cm^{-1} for the Ca^+ lines. One would expect values which are the sum of the gradients of the emitting atoms and the colliding particles. Only in special conditions, for example, if the density and temperature are independent of height, would the influence of the colliding particles be absent. A model which meets this condition consists of cone-shaped spicules which simulate a density and temperature distribution fairly constant with height. The fact that the degree of ionization of Fe appears fairly constant with height in the Khartoum observations (*Rech. astr. Obs. Utrecht*, **13**, no. 3, 1957) points to similar characteristics. Chromospheric models such as those of Athay and Thomas, or consideration of deviations from thermodynamical equilibrium could throw more light on this problem.

Results from the 1954 Gotland eclipse show an increasing intensity of the red coronal line down to about 4000 km above the base of the chromosphere. We are not yet able to explain all these facts and the need for further observations should be stressed.

In the discussion which followed Dr Athay said

I agree with Dr Houtgast on the need for careful observations of the lower chromosphere at the time of eclipse. The lowest 500 km of the chromosphere and the upper photosphere present one of the most challenging problems of the solar atmosphere since it is in this region where the outward increase of temperature seems to set in.

In regard to the interpretation of the low emission gradient in the wings of the strong lines in the low chromosphere, I think it is possible to explain this effect without resorting to departures from either spherical symmetry or thermodynamic equilibrium, although both are likely to exist. The same effect is found in the Balmer continuum emission, and in this case one must assume an outward increase in temperature in the lowest 500 km of the chromosphere. This same assumption offers a simple explanation for the low emission gradients in the line wings.

Finally, I would add that the observed strong emission from coronal lines at heights as low as 4000 km agrees with results that Dr Roberts and I found from our 1952 eclipse spectrograms.

After this, Mr Dyer was invited by the President to read a paper by Miss Vera C. Rubin on 'Solar Limb Darkening from Eclipse Observations'.

Photo-electric observations of the crescent during the total eclipse of the Sun on 1952 February 25 at three sites in Africa have been analysed to determine the coefficients which characterize the brightness distribution of the extreme limb of the Sun. The brightness distribution has been assumed to be of the form:

$$J(\rho) = c_0 + c_1 (1+\rho^2)^{\frac{1}{2}},$$

ρ is a dimensionless variable which varies from 0 at the centre of the solar disk to 1 at the limb. Lunar limb tracings supplied by Watts of the U.S. Naval Observatory have been employed to correct for the exact form of the lunar profile.

At 8000 Å the following conclusions have been obtained for $0{\cdot}988 \leqslant \rho \leqslant 0{\cdot}998$, that is, the outer 1·2 % of the solar radius:

(1) It is essential that corrections for the irregular lunar limb be included in such analyses; for crescents within ten seconds of second or third contact these corrections will in general be as large as 25 % or 50 % of the observed luminosity, and may even be as large as 90 %.

(2) There is a difference, Δt, between the times of predicted mid-totality and observed mid-totality at each site; the maximum $\Delta t = 1^{s}{\cdot}8 \pm 0^{s}{\cdot}17$ (m.e.), the minimum $\Delta t = 0^{s}{\cdot}51 \pm 0^{s}{\cdot}09$. It is assumed that this discrepancy is due to errors in the lunar and solar tables, the choice of parameters, and the assumed co-ordinates of the observer.

(3) The values of c_0 and c_1 are extremely sensitive to the choice of the semi-diameter of the Moon. In the past, an average of the low-lying lunar valleys was used in eclipse work to account in an approximate way for the irregular lunar profile. When exact limb corrections are used, a larger lunar semi-diameter is necessary. Computations have been carried out with both the occultation and the eclipse semi-diameters. The results are tabulated below:

Site	c_1/c_0 (Occultation Moon)	c_1/c_0 (Eclipse Moon)
Khartoum	3·3 ± 1·2 (m.e.)	17·7 ± 3·3
Bangui	3·9 ± 1·7	25·0 ± 7·8
Libreville	7·7 ± 1·4	28·4 ± 11
Combined solution for all sites	4·4 ± 1·4	22 ± 3

In remarks on this paper Mrs Gossner said:

(1) The discrepancies between observed and computed times of eclipse contacts may be due not only to the uncertainty in the constants used in the predictions, but also to the fact that ΔT (the difference between ephemeris and universal times) is known with any degree of accuracy only in arrears. The difference between the true and estimated values of ΔT affects the position of the observer with respect to the central line, and hence the duration of totality at the site.

(2) The recurrent controversy concerning the value of the diameter of the Moon to be used in eclipse predictions could be solved in a simple way. The difference between the so-called 'eclipse' diameter and the 'occultation' diameter affects only the tabulated values of the radii of umbra and penumbra. The change from one diameter to the other may be effected simply by the addition (or subtraction) of a constant to both radii, while radii for intermediate values may be obtained by linear interpolation. Mrs Gossner was prepared to communicate to the President of Commission 13 the value of this constant for forthcoming eclipses and this would allow each observer to select the lunar diameter most suitable for his observations.

Professor Mikhailov remarked that in the computations the main source of error lies in the reduction of the co-ordinates of the observer to the centre of mass of the Earth.

Dr Hubenet emphasized that the original measurements of the crescent intensities should be published.

https://doi.org/10.1017/S0251107X00020800 Published online by Cambridge University Press

Dr Athay suggested that spectrographic observations could give information about separate points in the crescent.

Miss Bugoslavskaya then drew attention to the need for measurements of the motion of matter in the solar corona during an eclipse along the track of totality. There are only a few observations of this kind and these show that coronal clouds connected with prominences have large motions and that other structures in the corona show slow motions. The 1951 and 1954 observations with a coronagraph of 5 m focal length were reduced at the Sternberg Astronomical Institute with a blink comparator and the method seems valuable for the future.

Dr Pecker asked for simultaneous observations of the corona in monochromatic and in white light. Miss Bugoslavskaya agreed that this kind of observation, not yet made, would be very valuable.

The President thanked Professor Mikhailov for his work as interpreter and closed the meeting.