12. COMMISSION DE PHYSIQUE SOLAIRE

PRÉSIDENT: M. C. E. ST JOHN, *Mount Wilson Observatory, Pasadena, Cal., U.S.A.*

MEMBRES: MM. Abbot, Abetti, Anderson, Bjerknes, Bosler, Brunner, Butler, W. W. Campbell, Carrasco, Carroll, Chapman, Curtis, Da Costa Lobo, C. R. Davidson, d'Azambuja, de la Baume Pluvinel, De Lury, Deslandres, Dingle, Donitch, Evershed, Favaro, A. Fowler, Freundlich, Hale, Jimenez-Landi, Lockyer, Menzel, Z. A. Merfield, Miller, Milne, Minnaert, Mitchell, Newall, Newbegin, Newton, Nicholson, O'Connor, Pannekoek, Pettit, H. H. Plaskett, Rodés, Royds, Sampson, Sekiguti, Slocum, Sôtome, Stetson, Störmer, Stratton, Unsöld, Van der Bilt.

SUGGESTED PROGRAMME

I. *Organisation.*

The president calls attention to the large and increasing membership of Commission 12 and the policy of concentrating in it all matters relating to the sun. The result makes it comparable in breadth of field and in membership to the former *Union for Co-operation in Solar Research.* The main point in favour of this policy is the increased interest in the meetings of the Commission and the larger number of individuals reached compared with the meetings of small committees. One recalls the general sessions of the Solar Union in which each one present felt himself a part of the Union and in real touch with the work of different sections and after the discussions went away with fuller knowledge of what it was all about. This was a valuable result not attained to the same degree from the general sessions of the present Union, but in a measure it does follow from the meetings of the Solar Physics Committee. On the other hand the question may be raised whether or not the merging of independent commissions into subdivisions of a large commission lessens their interest to an extent not balanced by the advantages. If the present policy holds, it seems to the president that a re-organisation of Commission 12 is advisable by which more responsibility is laid upon the directors of centres. The basis of membership in the Commission may well be considered and recommendations formulated for transmission to the Executive Committee.

II. *Spectrohelioscopic work.*

This bears a relation to Commission 12 similar to that of the spectroheliographic centre. Its inclusion will increase considerably the present membership of Commission 12, if all who take part in the active programme are added. A canvas shows the following stations at work or ready in the near future:

Observatory	
Royal	Greenwich, England
Solar Physics	Cambridge, England
Federal	Zürich, Switzerland
Astrophysical	Florence, Italy
American College	Beirut, Syria
Solar Physics	Kodaikanal, India
Terrestrial Magnetism	Watheroo, Australia
Carnegie Institution of Washington	Huancayo, Peru
National Institute	Nanking, China
Mount Wilson, Carnegie Institution of Washington	Pasadena, California

Observatory	
Pomona College	Claremont, California
Yerkes	Williams Bay, Wisconsin
Massachusetts Institute of Technology	Cambridge, Massachusetts
Franklin Institute	Philadelphia, Pennsylvania

M. d'Azambuja reports as follows:

J'ai installé à Meudon un dispositif permettant de transformer très rapidement en spectrohélioscope, le spectrohéliographe à réseau et chambre de 3^{m} qui sert quotidiennement à obtenir les spectrohéliogrammes $H\alpha$.

Il y avait une difficulté résultant du fait que la première et la seconde fente sont éloignées l'une de l'autre, de telle sorte que les prismes tournants d'Anderson utilisés ne pourraient être portés par un seul organe mécanique. Un premier prisme, de 15^{mm} de section, a été monté devant la première fente; un second, de 34^{mm} de section, pour tenir compte de l'agrandissement de l'image dans l'instrument, a été placé derrière la seconde fente. Les deux prismes ont été reliés par une transmission mécanique qui a coûté quelque peine à établir, à cause de la nécessité de conserver la rotation des deux prismes rigoureusement en phase, mais qui marche maintenant de façon satisfaisante. Toute la partie mécanique et les prismes sont fixés au plafond de la salle et peuvent pivoter autour d'un axe horizontal, de manière à s'effacer rapidement.

Il y avait un double intérêt à transformer le spectrohéliographe en spectrohélioscope plutôt qu'à constituer deux appareils indépendants: (1) on économise un réseau, (2) on peut plus photographier presque instantanément la phase intéressante du phénomène que l'on vient d'observer visuellement; même sans toucher aux prismes, en les orientant simplement de manière qu'une face soit perpendiculaire au faisceau, on peut placer le chassis photographique dans l'appareil et obtenir en moins d'une minute, l'image du phénomène étudié. On en conserve ainsi un document qui pourra être étudié à loisir, dans tous ces détails, ce qui est précieux si l'évolution du phénomène est rapide.

L'Observatoire de Meudon est disposé à coopérer aux observations avec le spectrohélioscope dans l'avenir.

III. *Consideration of the Report of the Committee on the Bulletin for Character Figures of Solar Phenomena.*

IV. *Problems of the Solar Atmosphere.*

Professor Milne asks for suggestions for observational tests of theoretical deduction or exploratory programmes on the following topics:

1. The sun's continuous spectrum between the absorption lines.
2. Contours of Fraunhofer lines.
3. Researches which can be carried out on spectroheliograms, or by means of adaptations of the spectroheliograph.
4. Sun-spots and faculae, at various points of the disc.
5. The physical relation of the layers contributing the Fraunhofer spectrum to those contributing the flash spectrum.
6. Photometric observations on prominences with the object of elucidating their density-distributions.
7. The corona photographed without an eclipse.

V. *Reports from the 1932 eclipse.*
VI. *Considerations of recommendations and unfinished business.*
VII. *Subventions.* Arcetri, Meudon.
VIII. *Special reports and topics. Lantern slides of interesting phenomena and new instruments.*

Reports from the Centres

1. *Sun-spots: Drawings. Visual. Stonyhurst.* Rowland:

The work of the observatory was carried on under the direction of Father O'Connor till 1932 June, when he was appointed Rector of the College, and the writer was appointed to succeed him as Director of the Observatory.

The systematic observation of sun-spots and faculae has been continued, and the results of measurements of areas and positions of sun-spots have been published in the annual reports of the observatory. By the co-operation of Prof. Brunner of Zürich, and Prof. Favaro of Catania, who have kindly supplied drawings for the dates when no observation was obtained at Stonyhurst, it has been possible to give measurements for nearly all days—the number of days for which no statistics are available in 1931 being only four.

In accordance with the resolution adopted at Leiden in 1928, counts of the numbers of groups and nuclei in the whole disc and in the central area of half the disc radius have been made for each day of observation, and the numbers sent to Zürich for use in the evaluation of the character index.

With a view to providing material for the study of the relation between solar activity and terrestrial magnetic disturbances, Father O'Connor began the preparation of a series of synoptic charts of the sun's surface for each rotation, with a reduced replica of the Horizontal Force magnetogram below it, so that the relation of magnetic disturbance to the occurrence and position of spots and faculae might be immediately apparent. The series was drawn from the beginning of 1925 to 1932, and it was hoped to be able to publish the charts for this period, and subsequently to issue them regularly as soon as possible after the end of each rotation, but so far this has not been found possible owing to lack of funds. A simpler chart by the writer showing the excess of magnetic disturbance on each day over the mean for the five quietest days of each month, arranged in 27-day periods in vertical sequence, has been published in our annual reports for 1930 and 1931, and will be continued. It shows clearly a number of sequences of magnetic disturbances at approximately 27 days interval, extending over many solar rotations, but a preliminary examination indicates that these disturbances do not show any close correlation with presence of sun-spots near the central meridian on the days of occurrence of the disturbances.

A spectrohelioscope is being erected at the observatory, and it is hoped to bring it into regular service before the end of the year.

2. *Sun-spots: Positions and Areas. Photographic. Greenwich.* Newton:

The measurement of positions and areas of sun-spots and faculae has proceeded at Greenwich as usual, the series of photographs being made up from those from the Cape of Good Hope, Greenwich, and Kodaikanal. An occasional photograph to complete the measurement of the series has been lent by Ebro, Mount Wilson and Yerkes. The *Greenwich Photoheliographic Results* have been published for the years 1927 to 1930. Current measures of the positions and areas of sun-spots and flocculi determined at Ebro have been published in *Boletin Mensual del Observatorio del*

Ebro. The Naval Observatory, Washington, in co-operation with Harvard, Mount Wilson, Perkins and Yerkes, has likewise published in the *Monthly Weather Review* current data of positions and areas measured from photographs taken at those observatories.

Catalogues of magnetic storms observed at Greenwich from 1874 to 1927 together with comparative sun-spot data were published in the *Greenwich Results* for 1927. The catalogues are brought up to date by yearly summaries published in *The Observatory*. Further discussion of these magnetic and sun-spot data is given in *Monthly Notices*, **88**, 556, 1928; **89**, 84, 1928; **89**, 641, 1929. It was found that the more intense magnetic disturbances were accompanied by an increase in the average area of the largest group of sun-spots present in the central part of the disc (longitude 53° East to 53° West) at the time of the commencement of the disturbances. No such increase was shown by the corresponding relative values of the areas of sun-spots near the sun's limb.

3. *Sun-spots: Polarities. Visual spectroscopic. Mount Wilson.* Nicholson:

At the 150-foot tower telescope visual observations of the magnetic polarity and field strength of all spots are made daily. As the minimum of the cycle approaches, observations of magnetic polarities in the spots become more and more important because of the probability that the polarity distribution within the groups will reverse as it has at the last two minima. Any check observations at this critical phase are especially valuable. All high latitude groups should be examined with special care. The average number of groups with polarities opposite to the regular distribution for the cycle is about three per cent. of the total so that the law of polarity distribution for the next cycle cannot be definitely established until several groups of the new cycle have been observed.

In connection with the probable reversal of polarities it is extremely important to look for any other differences exhibited by spots of alternate cycles. The amplitude of the spot cycle has been alternately high and low for several cycles, but this is the only difference between alternate cycles that has been detected except the reversal of magnetic polarities.

4. *Sun-spot Numbers. Zürich.* Brunner:

The sun-spot numbers deduced alone from the observations at Zürich and its station at Arosa have been regularly published at the end of each quarter of the year in the *Meteorologische Zeitschrift*, in the *Journal of Terrestrial Magnetism and Atmospheric Electricity*, and in the *Monthly Weather Review*. These are the provisional Zürich sun-spot numbers. They are not quite complete and show some gaps here and there from lack of observations at Zürich or at Arosa.

The final sun-spot numbers are the result of the Zürich observations supplemented by a great number of foreign series, by which all the gaps in our own series (40–50 yearly) are filled and the list made as complete as possible for every day of the year. Countings of sun-spot numbers are being regularly received from the following observatories: Batavia, Catania, Greenwich, Kiew, Kelburn (Wellington), Lyons, Roma (Campidoglio), South Hadley, Stonyhurst and Tokyo as well as from about forty private astronomers.

The final relative sun-spot numbers for the whole disc and for a semi-diameter circular zone are published in the *Astronomische Mitteilungen der Eidgen. Sternwarte* and in the *Bulletin for Character Figures of Solar Phenomena*, Nos. 1–16. The last issue of the *Astronomische Mitteilungen* is that of 1931. The Wolf numbers for the spot activity in the central zone for the years 1917–27 are given in the *Terrestrial Magnetism and Atmospheric Electricity*, December 1928.

5. *Prominences: Areas at the Limb. Visual and Spectroscopic. Arcetri.* Abetti:

Observations of prominences at the limb have been continued during the last four years at Arcetri, Catania, Madrid and Zürich. It is regretted that the observations at Zo-sè, which are of value because of the difference in longitude, had to be interrupted owing to the conditions in China. The summary of the results to the end of 1931 has been published regularly in the *Memorie e Osservazioni del R. Osservatorio di Arcetri*.

The height of the chromosphere has been measured uninterruptedly at Arcetri, Catania and Madrid. It will be interesting to see if the increased height of the chromosphere at the poles of the sun, noted at Arcetri at the beginning of the present cycle, will be confirmed in subsequent years. If so it means that the chromosphere undergoes systematic fluctuations, possibly due to currents in the high chromospheric strata, as is the case with the prominences. In order to correlate these phenomena, research has been commenced at the Arcetri Observatory to establish, in the best possible way, the shifting of the prominences towards the equator and towards the poles during the various cycles.

The 4-metre spectroheliograph of the tower telescope has been in regular use for taking Hα plates. Up to June 1931 the large size image of the sun (17 cm.) was employed; from July to October 1931 an image of 5 cm. and from October 1921 an image of 6·5 cm., which is best adapted to the local conditions, have been employed. At the beginning of 1931 a new grating, ruled by Jacomini, and kindly presented to this Observatory by the Mount Wilson Observatory, has been mounted on the spectroheliograph. It is a great improvement on the grating previously used and it is now possible to take not only Hα images but also K_3 images. The characteristic figures for bright and dark Hα flocculi have been regularly sent to Zürich for the International Bulletin.

The papers issued by this Observatory which deal with the above items are:

In the *Osservazioni e Memorie del R. Osservatorio di Arcetri*, fasc. 45–9.
- Visual observations of prominences and of the chromosphere, 1925–30.
- Eruptive prominence, May 14, 1928.
- On the presence of molecular hydrogen in the sun-spots.
- On the rotation period of the solar chromosphere.
- Oxides and hydrides in the solar atmosphere.
- Determination of the sun's rotation period in the green region of the spectrum.
- On the profile of the magnesium triplet in the solar spectrum.

In the *Rendiconti della R. Accademia dei Lincei*, **10**, **11**, **13**, **14**, 1929–31:
- Height of the chromosphere and the present solar cycle.
- Microphotometric measures of Hα at the centre and at the sun's limb.
- On the contour of the line 5183 *Mg* in the sun's spectrum.
- Emission lines in the spectrum of the sun's limb.
- Character figures of solar activity.
- Period of rotation and shifts at the sun's limb deduced from the emission lines.

6. *Prominences: Areas at the Limb. Spectroheliographic. Hα absorption markings on the disc. Kodaikanal.* Royds:

The number of observatories actively co-operating for the statistics from spectroheliographic observations of prominences and of Hα absorption markings remains (up to the data for 1930) the same as before, namely the observatories of Kodaikanal, Mount Wilson, Meudon, Pitch Hill (Mr Evershed's) and Yerkes. Below are given the numbers of days in the year for which spectroheliograms from at least one observatory are available, taking the average for the seven years 1924–30*. It will be seen that a greater reduction for imperfect photographs is necessary for calcium prominence plates than for hydrogen disc plates. This is partly due to the fact that on some days only calcium disc plates on which a few prominences are

	Average number of days in the year for which spectroheliograms are available	
	Actual	Effective
Prominence spectroheliograms	360	323
Hydrogen disc spectroheliograms	356	344

visible are available. No improvement is possible in this respect unless more observatories are in a position to supply prominence photographs.

The area of an Hα dark marking does not remain constant as the marking crosses the sun's disc and it has been the practice to correct the observed areas for foreshortening near the limb of the sun. It now appears desirable to drop this correction and from 1929 onwards the Kodaikanal Observatory Bulletins contain the uncorrected areas (i.e. the areas as projected on the sun's disc), in addition to the corrected areas which are still published for continuity with previous bulletins. Mr M. Salaruddin of the Kodaikanal Observatory has almost completed the measurement of the average change of area as an Hα dark marking crosses the sun's disc.

The relative intensities of different spectral lines in prominences have been measured by several observers. Perepelkin† finds that the ratio of intensities Hα : D_3 decreases with increasing height. Minnaert and Slob's‡ measures for Hα : D_3 do not agree with Perepelkin's, and the former interpret the varying ratio by varying self-absorption of Hα. They have also measured the intensity ratios H : K, and Hγ : Hδ : Hε. Slob§ has continued observations of the ratio H : K and finds a value decreasing with height instead of Minnaert and Slob's constant ratio. Pettit|| has compared spectrohelioscope observations of prominences in Hα with spectroheliograms in calcium K line, observing mainly quiescent prominences and those active ones which are drawn to an area of attraction on the sun's surface. He finds that prominences generally show the same form in Hα and in K, even to considerable detail, except that moving streamers and knots in the active prominences are either absent in Hα, or only represented by thin lines where there are broad ribbons in K. He interprets this as evidence that the attractive force is electrical in origin and also finds evidence of repulsive electrical forces.

From the end of 1928 the Kodaikanal Observatory has taken spectroheliograms of

* Co-operation under the I.A.U. was begun in 1923 but the number of days of observation in that year was notably less than for succeeding years.

† Perepelkin, *Zeits. f. Phys.* **49**, 295.

‡ Minnaert and Slob, *B.A.N.* No. 187, 176, 1930.

§ Slob, *B.A.N.* No. 218, 120, 1931.

|| Pettit, *Publ. A.S. Pacific*, **63**, 207, 1931.

prominences in Hα as part of the daily programme, in addition to K spectroheliograms. A comparison of these Hα and K plates leads to the following conclusions:

1. Generally speaking, Hα prominences are identical in shape and size (in agreement with Pettit) and in movement with K prominences. There are many days where the Hα plate for the whole of the sun's limb is practically indistinguishable from the K plate.

2. The essential identity of Hα and K prominences holds not only for quiescent and changing prominences, but also for eruptive prominences, even very high ones such as the prominence of November 19, 1928*. Eruptive prominences are, however, usually relatively fainter in Hα light, and the faintest parts of the prominence may be missing in Hα.

3. The fainter parts of K prominences are generally not so strong, or entirely absent, in Hα plates; i.e. the contrast in density in different parts of a prominence is greater for Hα than for K. The effect is that the Hα prominence often appears as a skeleton of the K prominence. It appears improbable that this effect is due either to different characteristic properties of the photographic plates employed, or to Doppler effect.

4. Occasionally prominences, or parts of them, which are intense in K are relatively faint in Hα. Sufficient evidence is not yet available to indicate whether this is due to Doppler effect.

These results are opposed to the theory that prominences are supported, or repelled from the sun, by radiation pressure. If, in particular, eruptive prominences are identical in shape, size and movement in Hα and Ca^+, then radiation pressure alone cannot be the repelling force. Eclipse photographs show that certain prominences are identical in general outline for Ca^+, H, He, and Sr^+ on which the radiation pressures must be of entirely different orders of magnitude. On the other hand, Perepelkin† would support the theory of radiation pressure by his observations of the ratio of Doppler displacements in the lines of Ca^+ and H in prominences.

7. *Flocculi and Prominences: Motions and Forms combined with radial velocities. Meudon.* d'Azambuja:

L'enregistrement de la couche supérieure de la chromosphère (images K_3 et Hα), de la couche basse (images K_1) et des vitesses radiales de la vapeur de calcium ionisé par la méthode du spectroenregistreur de Deslandres, a été poursuivi régulièrement avec les deux spectrohéliographes de 3^m, la moyenne annuelle des jours d'observation, pour la période 1928–31, étant de 236.

Les spectrohéliogrammes obtenus ont été utilisés, en premier lieu, à établir les cartes synoptiques de la chromosphère que l'Observatoire publie sous les auspices de l'Union astronomique internationale. Rappelons que ces cartes fournissent, pour chaque rotation synodique du soleil, les formes et les positions moyennes des *filaments* (protubérances en projection sur le disque) et des plages *faculaires* (groupes de flocculi) du calcium ionisé, au cours de leur passage dans l'hémisphère visible. Des teintes et des signes conventionnels appropriés indiquent, de plus, l'intensité des plages, les mouvements propres des filaments et leur degré de persistance. Les taches sont figurées schématiquement. En regard de chaque carte, est placé un tableau qui précise les caractères des filaments et indique qualitativement leurs vitesses radiales. L'ensemble des tableaux forme un catalogue des filaments.

* *M.N. R.A.S.* **89**, 255, 1929.
† Perepelkin, *C.R. Acad. Sci. URSS*, Dec. 19, 1929.

A la fin de 1932, l'ouvrage s'étendra à une période undécennale complète (1919–30), fournissant ainsi les éléments d'une étude d'ensemble des phénomènes représentés. Cette étude, déjà commencée, portera notamment sur les vitesses de rotation des filaments et leur élévation au-dessus de la chromosphère.

Pour toutes les séries de cartes établies, une partie notable des lacunes de nos observations a été comblée à l'aide de spectrohéliogrammes K_3 ou $H\alpha$ obtenus des Observatoires de Coïmbra, du Mont Wilson et de Kodaikanal. De notre côté, nous avons envoyé à ce dernier établissement les images K_3 et $H\alpha$ qui nous ont été demandées pour la statistique des protubérances et des "$H\alpha$ Dark Markings."

Des cartes synoptiques provisoires, dressées plus sommairement d'après les seuls documents de Meudon, ont été publiées mensuellement dans le *Bulletin de la Société astronomique de France*, depuis mars 1929.

L'Observatoire a participé régulièrement à la détermination des nombres caractéristiques de l'activité solaire pour les plages faculaires du calcium (calcium flocculi), les plages faculaires de l'hydrogène (Bright $H\alpha$ flocculi) et les filaments (Dark $H\alpha$ flocculi). L'origine de la publication de ces nombres avait été fixée à 1928 par le Congrès de Leyde. Ultérieurement, on l'a fait remonter à 1913. Cette nouvelle période de quinze ans comportait, pour Meudon, plus de 13,000 nombres caractéristiques à déterminer. Cette tâche considérable a pu être accomplie grâce à une subvention de £40 que lui a accordée le Comité exécutif de l'U.A.I. et qui lui a permis d'adjoindre, pendant quelques mois, un assistant supplémentaire à son service de physique solaire.

L'Observatoire a participé également au service quotidien d'informations géophysiques et astrophysiques par radiodiffusion (Ursigrammes), organisé depuis le 1er décembre 1928 sur l'initiative de l'Union radiotélégraphique scientifique internationale. Les renseignements fournis par Meudon, pour chaque jour d'observation au spectrohéliographe, concernent l'état d'activité des taches, des plages faculaires et des protubérances extérieures au bord ou en projection sur le disque.

Dans l'intervalle des observations courantes, j'ai pu compléter, avec le grand spectrohéliographe double, à trois fentes, dont le pouvoir dispersif atteint, en moyenne, 1·3 A au millimètre, une série de recherches commencée en 1926 sur la structure des images données par les différentes parties de onze raies de la couche renversante, appartenant à cinq éléments différents: fer, calcium, magnésium, sodium neutres; strontium ionisé. Ces recherches, publiées en 1930 (*Annales de Meudon*, **8**, fasc. II), ont révélé que les détails observés sur les images devaient être classés en deux catégories: ceux dont l'existence est due aux variations du rayonnement de la surface et qui sont communs à toutes les images chromosphériques, et ceux qui correspondent à ce que j'ai appelé la *structure propre des vapeurs*. Le caractère essentiel de cette structure consiste en une granulation analogue à celle des images $H\alpha$ de l'hydrogène dans les régions du disque non troublées. Des spectrohéliogrammes obtenus *simultanément* avec une raie du fer et une raie du calcium neutre ont même permis de vérifier qu'elle est, au même instant, sensiblement identique pour les deux éléments. L'investigation a été étendue aux deux raies infra-rouges du calcium ionisé λ 8542 et λ 8498. Les images nouvelles enregistrées, qui participent des images K_2 et K_3, laissent aussi soupçonner la structure granulaire. Celle-ci serait donc tout à fait générale dans les vapeurs chromosphériques, aussi bien dans les couches basses qu'aux niveaux élevés de $H\alpha$ et du calcium ionisé.

L'épaisseur, au bord solaire, des vapeurs étudiées, a été mesurée en comparant les diamètres d'images faites à intervalles de temps très rapprochés avec une des raies analysées et avec une étroite portion du spectre continu voisin. La méthode s'est révélée efficace. Elle a donné des épaisseurs comprises entre 700 et 2300 kilomètres, suivant les raies considérées. Nous nous proposons de l'appliquer systématiquement aux radiations de niveaux élevés K_3 et $H\alpha$. Les résultats atteindront probablement une précision supérieure à celle que fournit la mesure directe de la saillie des raies.

Un dispositif, permettant de transformer très rapidement le spectrohéliographe de 3 m., à réseau, en spectrohélioscope, a été réalisé à Meudon. Il permettra de fixer par la photographie les phases intéressantes des phénomènes chromosphériques observés visuellement.

8. *Solar Radiation. Washington.* Abbot:

The text of Volume 5 of the *Annals of the Smithsonian Astrophysical Observatory*, covering the work of all its observing stations since 1920, was completed in August 1931. Page proof was finally revised in January 1932.

Three desert mountain solar radiation stations in Southern California, Chile, and South West Africa agreed in fixing the monthly mean values of solar radiation to 0·1 per cent. Fluctuations of the sun's radiation are clearly indicated harmoniously by all three stations. The largest range of monthly mean values occurred in 1922 and reached nearly 3 per cent. The second largest in 1928 reached 1·2 per cent. Daily values from different stations are less harmonious mainly because neither the Californian nor the African station is of sufficient excellence. A reconnaissance is in progress to find another station in the world equal to Montezuma, Chile, but so far without success. The extreme range of solar variation since 1920 appears to reach 5 per cent.

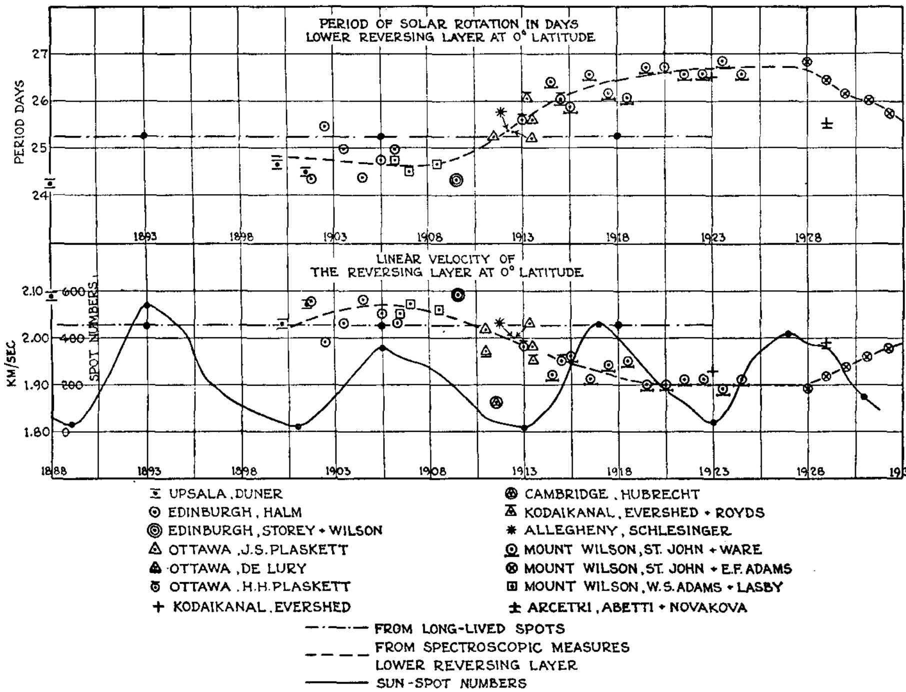
The variations of the monthly mean solar constant values have been adequately represented as the sum of five regular periodicities, viz. 8, 11, 25, 45 and 68 months. The same periodicities have been found in the departures from normal temperatures of Washington, D.C., and Williston, N.D. A new machine called the periodometer, devised by C. G. Abbot, has been constructed with aid from the Research Corporation of New York. It is in active use discovering and evaluating the periodicities in solar and weather phenomena. A fair hope is entertained that results of real value for forecasting purposes months and years in advance will result.

During a visit to the Meteorological Observatory at Potsdam, a comparison was made on two fine days with Dr Martens between the silver-disk pyrheliometer furnished them by the Smithsonian Institution in 1912 and one recently standardised in Washington. No change since 1912 was indicated. The water-flow pyrheliometer is being rebuilt and improved. It is expected to use it as a primary standard at Mount Wilson in 1932.

9. *Solar Rotation. Mount Wilson.* St John:

Evershed has measured the rotation given by the H and K lines of prominences and finds a daily angular motion about 27 per cent. greater than for spots. The observations refer to a mean height of 34″. There is no evidence of polar retardation. The rapid angular rotation is apparently not confirmed by direct observation of prominences at the limb, indicating that it is the point of origin that rotates with the speed of the photosphere, while the prominence material is driven westward over the sun.

At Arcetri the period of rotation has been deduced for the lines $H\alpha_2$ and $H\alpha_3$ from plates taken with the 4-metre spectrograph of the solar tower, and is in good agreement with previous results for the upper chromosphere. Values have been obtained in 1929 for a few lines of the reversing layer in the red region and in 1930 for several lines in the green one. In addition, values for the period of rotation have been obtained from plates of the upper chromosphere taken with the 150-foot tower at Mount Wilson, by measuring the bright emission lines in the green region. From these various results, it appears that the difference in the values of the rotation is due, not only to the various spectral lines from which they are deduced, but also to the point of the limb under observation, namely outside of the limb, limb and inside of the limb, and consequently to the size of the sun's image employed in the various determinations.



At Mount Wilson the present series of observations was begun in 1914 and has continued with short intermission to the present. Their importance depends upon the use of the same equipment, the 150-foot tower telescope and 75-foot spectrograph, for the whole series with one change in the measurers. The new measurer had had a long experience in similar work and was checked against the former. Simultaneous observations have been made at different times—150-foot equipment and 60-foot tower telescope; 150-foot and the 60-foot Snow telescope. The measures have agreed within the limits of accuracy and show that the low values do not depend upon the instrumental equipment.

The results from the 18-year series together with those from earlier observations at Mount Wilson and elsewhere, when plotted against years as abscissae, show a progressive change in the equatorial rotation determined from the reversing layer during the past thirty years greater than can be attributed to errors of observation.

On the other hand the rotation determined from observations on sun-spots by the Greenwich observers shows no variation during the same time.

On the assumption that the rotation of the sun from spots is a measure of the rotation of the photosphere, the linear velocity of the reversing layer in 1906 was 0·06 km./sec. greater than that of the photosphere and in 1918 0·10 km./sec. less, reaching a long minimum around 1925 when the period of rotation was about two days longer than in 1906. Since 1928 the Mount Wilson observations show fairly regular increase of velocity which, however, remains up to the present less than that of the photosphere. The observations are best interpreted as alternately eastward and westward drifts of the reversing layer of long periods. From the importance of the subject it is desirable that observatories join in an observing programme that deals with actually changing conditions on the sun and offers interesting problems.

10. *Report from Committee on Bulletin for Character Figures of Solar Phenomena.* Abetti and Brunner:

With the object of providing early information about the varying conditions of solar activity it was decided at the last meeting of the Astronomical Union to publish a quarterly bulletin of daily character figures of various solar phenomena. The Swiss Federal Observatory (Eidgen. Sternwarte in Zürich) has been charged with the collection of the material and the publication of the bulletin.

This bulletin has been issued quarterly for the period from January 1928 onwards. The cost has been met by annual grants made for this purpose by the International Research Council, on the recommendation of the commission appointed to further the study of solar and terrestrial relationships. These grants, made originally for three years, were extended by the council for a fourth year to cover the year 1931, and the committee recommended annual grants also, each not exceeding £40, for the three years 1932–34.

Co-operating observatories are: Arcetri-Firenze, Cambridge, del Ebro, Kodaikanal, Lyons, Kiew, Meudon-Paris, Mount Wilson, Roma-Campidoglio, Stonyhurst, Tokyo and Zürich. The bulletin contains daily character figures for spot activity, for calcium flocculi, for bright and dark Hα flocculi and for the intensity of ultra-violet radiation. The spot and flocculi numbers are given for the whole disc and for a smaller central part of the sun's surface which is turned more towards the earth. The central zone is a concentric circle of a diameter equal to the radius of the sun's disc. The character figures are assigned on a scale of numbers from 0–5. The numbers refer to the area and intensity of the flocculi, 0 representing absence and 5 extreme abundance and intensity. Special disturbance, unusual brightness, great changes of activity are mentioned in footnotes. The intensity of spot activity for the whole disc, as well as for the central zone, is expressed for each day by the Wolf relative spot numbers. Passages of large or average-sized groups through the central meridian, new formations of spot groups and entrance of a large or average-sized centre of activity on the east limb are pointed out in special notes. The figures for the intensity of the ultra-violet radiation give the ratio ultra-violet ($\lambda = 0{\cdot}32$) to green ($\lambda = 0{\cdot}50$).

The bulletin has now been published for nearly four years. On going through the figures for the calcium flocculi and the bright and dark hydrogen flocculi, we see that the figures for the same day from different observatories deviate from each other and the deviation is often greater than the personal error admissible in forming the estimates. It is desirable to investigate the cause of these discrepancies with the view to eliminating them as far as possible. A certain disparity in the values of different observatories for the same day is of course to be expected, the numbers not being determined by measurements but by estimation only. Deviations of one unit in the scale 0–5 have to be taken into account, particularly in times of greater activity.

The first cause of such disparities is undoubtedly the degree of accuracy with which the second slit of the spectroheliograph is directed on the H and K calcium lines or on the Hα hydrogen line. A slight shift of the slit to one side or the other of the centre of those lines leads to a change in the feature of the flocculi, both as regards their area and their intensity. For the bright and dark hydrogen flocculi the daily reports vary more. That is to be expected. In fact the line Hα is narrower in Angström units than the line K for calcium. Hence it follows that with equal dispersion a given error in the position of the second slit affects the aspect of the Hα images more than those of calcium. So far no numbers have been excluded. The question is whether it would not be advisable to leave out the number quoted by an observatory when it is considerably below the figures for the same day of two or three other stations.

Such discrepancies may be secondly due to atmospheric conditions, that is to the steadiness and transparency of the air. This cause may be avoided by rejecting all observations made under unfavourable atmospheric conditions.

A third cause is the different scale used at the different observatories for the estimates of the character figures. From a large number of spectroheliograms with a solar image of about 6 cm. at Mount Wilson, six of each kind of flocculi have been selected as representing as closely as possible the intensity and area of the flocculi on a scale of 0–5. It would be of great help to avoid systematic differences between the various stations if copies of the selected spectroheliograms were distributed so that all stations might conform to that standard scale.

A fourth source of considerable discrepancies in the character figures may be the smaller number of observations obtained at a station. In order to determine the index-number for a given day it is necessary to examine whenever possible the plates of the days before and after the day in question. By this method too high or too low estimates can be avoided.

Lastly another cause of the discrepancies may be the difference in the time of observation at the different observatories around the earth, especially in times of greater activity when passing eruptions are more frequent.

The character figures in the bulletin are given for every single co-operating observatory. The figures are then averaged to obtain a daily mean. An attempt has been made to reduce the figures to a chosen standard series by means of correction factors. We have come to the conclusion, however, that the numbers will not be noticeably improved in this way.

The bulletins issued have been forwarded to a large number of institutions and individual investigators according to a list drawn up in co-operation with the International Unions of Astronomy, Geodesy, Geophysics and Radiotelegraphy. It is to be hoped that they will be of service in the investigation of solar and terrestrial relationships.

The sub-committee which has organised the preparation of the bulletin considered it desirable to extend the series of daily character figures to the years prior to 1928. The International Astronomical Union has made a grant of £75 towards the publication of these numbers. The first series containing the character figures for 1923–28 is ready to be printed and will be issued in the spring of 1932.

To complete the data relating to solar activity it would be very useful to add the results of the observations with Hale's spectrohelioscope at the different stations.

With reference to terrestrial magnetism Dr Nicholson writes that the results emphasise the importance of localised solar activity of abnormal intensity and indicate that the records of such phenomena are perhaps the most important contribution to the bulletins. He suggests that it may even be desirable to establish a new character figure based on the intensity, rather than on the area, of the bright hydrogen flocculi.

Father Rodes gives a report on abrupt beginnings of magnetic and electrotelluric storms. About two thousand records have been examined by Father Puig and from them it appears that there is a daily period with a minimum at 6^h G.C.T. and a sharp maximum at 21^h. Statistical observations of other observatories are wanted.

Regarding the ultra-violet solar radiation we draw attention to the recommendations of the Commission for the Study of Solar and Terrestrial Relationships (*Third Report*, p. 3), and to the conclusion that further investigation is necessary into the variations recorded by existing methods, as for instance at Mount Wilson, and published in the bulletin. Spectrophotometric measurements made by comparison with standard sources of radiation should give more information on this problem.

Memoranda dealing with character figures of solar phenomena:

(1) Howell C. Brown, Correction Factors and Corrected Daily Means of the Solar Indices as given in the International Bulletins (*Terrestrial Magnetism and Atmospheric Electricity*, December 1930).

(2) Giorgio Abetti, On the Meaning of the Character Figures of Solar Phenomena (*Third Report of the Commission Appointed to further the Study of Solar and Terrestrial Relationships*, pp. 6–11, 1931).

(3) W. Brunner, On the Character Figures of Solar Phenomena (*Third Report of the Commission Appointed to further the Study of Solar and Terrestrial Relationships*, pp. 22–5, 1931).

(4) Kiyofusa Sôtome, On the Correlation between Sun-spots, Calcium Flocculi and the Radiation of the Sun (*Proceedings of the Imperial Academy*, **7**, No. 5, 1931).

(5) Seth B. Nicholson, Solar Character Figures (*Third Report of the Commission Appointed to further the Study of Solar and Terrestrial Relationships*, p. 103, 1931).

11. *Eclipses. Cambridge, England.* Stratton:

(*a*) *Coming eclipses*

The following information about the belt of totality for the eclipse of February 14, 1934, has been obtained by Dr Minnaert.

Borneo. The central line crosses the east coast near 1° 55′ N. The conditions do not appear to be very favourable. The great Berace river probably means fog in the early morning on the coast and the more central parts of the island are not easily accessible. The sun is so low at totality that observations would be difficult.

Celebes. Latitude of the central line 1° 7′ N. The N.W. monsoon makes the N.W. coast undesirable. The central part of the island would be favourable because the altitude is high and the climate agreeable, but in February fog is frequent in the morning over the central parts. The S.E. coast seems the most suitable site, especially Ratahan (1° 5′ N., 124° 47′ E.), Sindoran (1° 7′ N., 124° 56′ E.) or a guesthouse (pasanggerahan) between Ratahan and the coast on the motor road to Ratahan. At Sindoran there is a coffee plantation. Regular sunshine observations round the date and hour of totality are being organised by the Observatory at

Batavia. The K.P.M. Steamship line has a regular service to Celebes. Baggage would have to be unloaded by shore boats from the steamer.

Halmaheira. Probably Boeli (0° 50′ N., 128° 15′ E.) on the east coast is the best place. The rainfall, 233 mm. for February, is higher here than on the S.E. coast of Celebes (144 mm.). Sunshine records are not yet available.

Ternate. This island is dominated by a mountain peak which is likely to attract clouds. Sunshine data are lacking.

(*b*) *Eclipse problems*

There is no need to repeat here the discussion of important eclipse problems made in the last report of the eclipse centre to the Union.

Professor Freundlich's work on the deviation of the light in the gravitational field of the sun, with a long telescope at the eclipse of May 9, 1929, again gives a higher value than that predicted by Einstein. His results with an equatorially mounted telescope are not yet published. Further observational material is obviously still desirable at suitable eclipses. Dr Grotrian at the same eclipse obtained further data pointing to puzzling variations in the bright line spectrum of the corona which may help later in the elucidation of its source. He also observed a new line at λ 6704. The same investigator has confirmed Professor Ludendorff's results showing that the distribution of intensity in the continuous spectrum of the corona is the same as that of the sun. It remains to be seen whether a continuous coronal radiation can be disentangled from the scattered solar light in the lower corona at least.

Professor Mitchell observed the eclipse of October 1930 at Niaufou, and in his report, published in the *Astrophysical Journal*, summarises our knowledge of the spectrum of the corona. Including a new line at λ 6776 he considers 19 lines to be truly coronal, and that of these only two *pairs* of lines can be recognised with certainty, viz. $\lambda\lambda$ 3388 and 5303 and $\lambda\lambda$ 3601 and 4086.

M. Lyot's observations of the polarisation of the corona without eclipse (*C.R.* **191**, 834) suggest the value of co-operation with eclipse observers to confirm his results. Another polarisation effect that should be studied is the variation of polarisation with wave-length. This should have a decisive bearing on the source of the scattering of light in the corona, whether mainly by electrons or by atoms and ions.

The desirability of standardising all eclipse plates photometrically may be once more emphasised and the advantage for certain purposes of registering on a chronograph with electric contacts the exact moments when eclipse photographs were taken: this latter may be particularly useful for flash spectra.

The examination of the bright line spectra at the cusps and of the extreme limb spectra just outside totality should also lead to interesting and valuable results.

Dr Anderson suggests the following method of photographing shadow bands at a total eclipse. A screen of ground glass or oiled paper, about 2 m. by 3 m. is placed in the beam from the sun to a cinema camera and normally to the beam, so that the screen is in focus on the film of the camera. From about three minutes before second contact to about three minutes after third contact pictures may be made at the normal rate, the effective aperture of the lens being varied as the eclipse proceeds. Bad weather conditions have prevented success at several eclipses at which this simple apparatus has been tried.

(c) *Code for prominences to be expected on the limb of the eclipsed sun*

The following number code has been drawn up by Dr Royds, Director of the Kodaikanal Observatory, for use in indicating the probable state of the sun's limb to eclipse observers. This information may be helpful in enabling observers to decide on which of two flash spectra to concentrate or in what orientation to set such apparatus as an image rotator or a polariser. It is suggested that where eclipse observers wish for information about prominences they should arrange beforehand with the Directors of solar observatories to use this code in cabling such information as is available on the day of the eclipse.

Suggestions for code for telegraphing positions of prominences expected on eclipse day

The sun's limb is divided into four quadrants extending from the equator to the poles namely, N.E., S.E., S.W., and N.W. denoted by the figures 1, 2, 3 and 4 respectively. One "word" of five figures is devoted to each prominence. The first figure denotes the quadrant, the next two express the lower limit of its latitude and the last two the upper limit of its latitude; e.g. the word 20516 denotes a prominence expected in the S.E. quadrant extending from latitude $-5°$ E. to $-16°$ E.; 44551 would denote a prominence in the N.W. quadrant extending from $+45°$ W. to $+51°$ W. If the words of the telegram are arranged below one another, a vertical check word can be formed by adding; each column of figures should be added separately, entering only the units figure of each summation (i.e. the tens figure of each summation will not be added to the next column). For instance for the following prominences the check word would be 83151, not 94271.

$$\text{Prominences}\begin{cases}12538\\37175\\44558\end{cases}$$
$$\overline{83151}\ \text{check word.}$$

A horizontal check is hardly necessary, since the quadrants will be given in their serial order, and the last two figures of each prominence word must represent a number greater than the previous two figures.

Prominences which are forecast with reasonable certainty will be given first (referred to below as group I). A separator word will separate these from prominences which are probable but not certain. This separator word will commence with 999 which will be followed by the date of the month of the observations from which the forecast is made, e.g. 99905 would be the separator word if the last day of observation were the 5th of the month. It may happen that the day immediately preceding the eclipse is cloudy at the observatory; if the forecast is made for more than one day ahead it is not likely to be successful and therefore it seems desirable that the eclipse party should know the date of the observations on which the prediction is made. The separator word will be followed by less certain prominences, referred to below as group II, and their check word.

Example: The date April 12, 1926, was chosen at random from which to predict the prominences to be expected on the next day the 13th, supposing this to be the date of an eclipse. From the spectroheliograms of the 12th it was expected that prominences could certainly be expected on the 13th in the S.W. quadrant from latitudes 20° to 23° and 40° to 45°; in the N.W. quadrant from latitudes 42° to 52°. Prominences would also probably be seen in the N.E. quadrant from latitudes 30°

to 40° and 45° to 50°; in the S.E. quadrant from 20° to 25°. The telegram to be sent to the eclipse party would consequently be 32023 34045 44252 00210 99912 13040 14550 22025 49515, which would be arranged by the recipient as follows:

32023 34045 44252	Group I. Prominences certain to appear on the 13th.
00210	check word.
99912	separator word indicating date of observations.
13040 14550 22025	Group II. Prominences which are probable but less certain than the first group.
49515	check word.

Note 1. If group I or group II consists of only one prominence the check word will be the same as the prominence word.

Note 2. If there are no prominences in group I, the separator word will be the first word and if there are no prominences in group II the separator word will be the last.

With regard to this code we suggest that it should be made quite clear that the measurements relate to the earth's and not the sun's equator. Perhaps it might be as well to indicate the positions of the prominences by position angles as used in measurement of double stars. To keep to five units the hundreds of degrees should be left out for the second position angle of each prominence. Thus, assuming the figures in the first example apply to the earth's equator, the figures should read:

05265
19599
31528
―――
56392

We prefer carrying forward the units of the check addition as is done in the international code. This gets rid of the necessity of two entries for a prominence lying across the equator.

12. *Problems of the Solar Atmosphere. Oxford.* Milne:

Suggestions for observational tests and exploratory programmes are given on page 35 above. Professor H. H. Plaskett further suggests as a possible problem the determination, following d'Azambuja's method, of the maximum visibility of faculae and hence their position in optical depth in the line of sight (see *M.N. R.A.S.* **91**, 928, 1931). In addition the following memorandum is submitted by Dr Minnaert.

(*a*) *The Sun's Continuous Spectrum between the Absorption Lines*

The chief problems of interest for observers seem to me the following:

(1) The intensity distribution in the ultra-violet part of the spectrum. We may assume that the data of Fabry and Buisson on one side and those of Plaskett on the other are more or less satisfactory for the radiation of the sun's centre. However, for a theory of radiative equilibrium, it would be important to know also the

https://doi.org/10.1017/S0251107X00016412 Published online by Cambridge University Press

distribution of the ultra-violet light over the different parts of the disc. Now there seems to be here an inconsistency between the data of Schwarzschild and Villiger* and those of Fabry and Buisson†. The first two writers find a very steep decrease of the intensity towards the limb whereas the last ones affirm that the contrast was only moderate, and the same over the whole spectral range λ 3143–2922.

(2) The intensity distribution at the extreme limb of the sun. Probably direct measurements will not be able to furnish accurate data on this subject, and only measurements of the total radiation during eclipses, near the moment of totality, are really conclusive. I have formerly emphasised the importance of these measurements‡; since, the eclipse measurements of Stetson, Arnold and Johnson have furnished us with excellent data§. Only these ought to be supplemented by the same measurements in other colours.

(b) *The Brightness of Sun-spots*

Mr Wanders at Utrecht has made at my request some calculations concerning the composition of the radiation, emerging from a column of gas which is adiabatically expanding. The results disagree with the observations on sun-spots made by Pettit and Nicholson. The relative brightness of a spot compared with the neighbouring photosphere decreases with increasing wave-length, but the observed curves are somewhat steeper than the theoretical ones. This effect could perhaps be explained by the fact that Pettit and Nicholson had their solar image not focussed in the infra-red.The relative brightness should quickly decrease toward the limb, whereas the observations show an increase. This last effect is most important; if it were well established, we ought perhaps to assume over the spot a region where there is again radiative equilibrium. But the observations available are old ones. It is to be feared that the spot is partly "filled up" by photospheric light, scattered in the optical parts of our instruments or deviated by the scintillation; the nearer the spot comes to the limb the more it appears foreshortened, and the stronger the irradiation must be. The data therefore do not appear quite trustworthy.

The results are similar, if we allow for a variation of the absorption coefficient with depth. Here the curious fact is disclosed, that an ascending column of gas will not necessarily become darker, but may also become brighter than the surrounding photosphere; it is true that the temperature decreases everywhere in the column when this is ascending; but at the other side the absorption coefficient decreases also, and we look deeper into the sun. If the cooling is not strong ($\gamma > 1{\cdot}56$), the last effect will be predominant.

A third essay by Mr Wanders and myself was to consider a spot in an atmosphere of hydrogen, as suggested by Unsöld. The agreement with the observations is then very bad, the radiation in the spot diminishing only to 80 per cent. of that of the photosphere in the visual spectrum.

Finally, we attempted the somewhat bold hypothesis, that the visible layers of a spot are not in adiabatic equilibrium but in radiative equilibrium, the ascending movement which is the real cooling process having perhaps slowed down in the upper layers. It was found that by this hypothesis curves were obtained which agreed quite well with the observations. The contrast ought to increase only slightly towards the limb.

* *Ap. J.* **23**, 284, 1906.
† *Ap. J.* **54**, 318, 1921.
‡ *M.N. R.A.S.* **89**, 197, 1928.
§ *Ap. J.* **74**, 122, 1931.

We therefore think that, with the data now available, we must accept this modification of Russell's model. In the visible layers of a spot, the effect of the radiation largely predominates over the effect of the ascending current.

New observations on the radiation of spots at different positions and wave-lengths have already been started at Utrecht; it would be useful to have them checked by other observations.

Measurements of the contrast between a sun-spot and the neighbouring photosphere as a function of the position on the disc should be made in the best conditions of seeing. Only big spots should be used. The focus in the infra-red should be accurately known. Moreover, there should always be a correction for irradiation by observations of the false light outside the limb of the sun.

(c) *The Spectrum of Faculae*

Very little attention has been given to the spectrum of faculae. The only publications about it are some comparisons between the intensities of facula-lines and those of photospheric lines made by St John*. The differences are faint, and they can only be found by microphotometric measurements. It is clear that care must be taken to reduce the intensities in the two spectra so that the backgrounds become equally bright. Very probably, the differences in the spectrum will depend on the position of the facula on the disc, which therefore should be carefully noted, and on the position of the photospheric region to which the facula is compared.

It would be especially interesting to investigate (*a*) those lines which show a strong difference of intensity between the centre and the limb of the sun; (*b*) the lines which are considerably weakened or strengthened in sun-spots.

(d) *Contours of Fraunhofer Lines*

(1) Measurements of contours are of fundamental importance for a number of solar problems. Would it not be useful to select a number of strong lines, which should be recommended to all the observers working on this subject? By a comparison of their results, some really trustworthy contours could perhaps be obtained and the methods of measuring be tested.

(2) The intensities in the centre of strong lines. This problem is especially interesting for the resonance lines of elements other than hydrogen, because for these lines there is a contradiction between theory and observation. It was thought at first that collisions of the radiating atoms with electrons could explain the considerable residual intensities which are observed; but a more exact analysis, taking account of the varying electron pressure in the different layers of the sun, showed that this explanation is not valid. Exact values of the residual intensities are urgently needed as a guide for theory. I think that no measurements may be trusted if the authors have not calibrated the intensities of the ghosts of their grating. But here again there is a difficulty. This calibration is not easy: I find that the ghosts become intenser with increasing wave-length (in the same order)†; Professor Hestal informs me that he found the same phenomenon. On the other side, the theoretical result is that the relative intensity of the ghosts must be independent of wave-length. The experience of other observers would be welcome.

(3) The contour of the lines at the limb of the sun compared to that at the centre must furnish us with a criterion in order to distinguish between the two causes of

* *Phys. Rev.* **19**, 390, 1922.

† *Verh. Akad. Amst.* **30**, 257, 1921.

extinction: monochromatic scattering, and absorption by collisions of the second kind. It is perhaps better to observe the spectrum at a small but definite distance from the limb than at the extreme limb, where the scintillation begins to play a rôle.

(4) The *exact* measurement of the total absorption of lines of medium intensity (Rowland 2–8) gives the damping coefficient for that particular transition in the atom*. Such measurements would be of considerable importance.

(*e*) *The Polarisation of the Corona*†

Theory makes probable that the scattering of the light by the free electrons of the corona is many times stronger than that by the bound electrons. But if this is true, the polarisation should be nearly the same for all wave-lengths.

The older measurements of the polarisation seem to show a maximum polarisation of 35 % in the blue part of the spectrum, against only 12 % in the yellow part. This would not agree with the theoretical expectation, and would point to scattering by bound electrons. However, the examination of the original papers leaves the impression that the results obtained are by no means conclusive. These measurements were made photographically in the blue, visually in the yellow. It would be very important to repeat the measurements by the same method in both regions. Particular care must be taken to avoid scattered false light.

Such observations would furnish an important contribution to the theory of the continuous light of the corona and the explanation of its physical state.

The following theoretical problems are suggested as capable of solution.

E. A. Milne:

1. A discussion is required of the transition region in a stellar (or the solar) atmosphere between the region of local thermodynamic equilibrium and the region of monochromatic equilibrium. This should (*a*) give an improved formula for the theoretical contour of a spectral line; (*b*) reconcile the analysis for mechanical equilibrium of chromospheric type with that for mechanical equilibrium under gravity only, and so deal with the fit of high-level layers on to those at a lower level. These problems have already been considered by Menzel, Woolley, Eddington, and others (including the writer) but it is clear that some new method of technique is wanted.

2. In close connection with the same problem is that of reconciling the formula for residual intensity in an absorption line produced by a chromospheric column with that of the residual intensity calculated thermodynamically. The one formula involves g, surface gravity, the other depends only on atomic scattering and absorption coefficients. This problem has been hitherto neglected.

3. Fuller discussion is required of the state of affairs in a sun-spot, following the Evershed-St John picture of a spot as investigated theoretically by Russell, Petrie, the writer, and quite recently by Kosirev. A calculation on hydrodynamical lines, taking account of the lines of flow, pressure changes and temperature changes, with the object of calculating the theoretical effective temperature of the umbra is required. This is being considered by Cowling, who is also taking into account (following Unsöld) the effects of a probable excess of hydrogen.

4. It should be possible (the writer attempted this problem many years ago with only partial success) to calculate the radiation emergent from the top of an ionized

* M. Minnaert and G. F. W. Mulders, *Ztschr. f. Astroph.* **2**, 180, 1931.

† Cf. M. Minnaert, *Ztschr. f. Astroph.* **1**, 209, 1930.

column taking account of the fact that the ionized column extends downward indefinitely and is not limited by an assignable optical depth. (This problem has also been discussed recently by Menzel.) Each atom, in its mean state of ionization defined by the pressure and temperature of its surroundings, should be given its appropriate effect in contributing to the external radiation. It is quite practicable to develop suitable approximate formulae for this purpose (*not* empirical formulae) and to obtain asymptotic formulae for the integrals which arise.

5. A discussion of the meaning of "turbulence" and its possible origin is required. It must be remembered that turbulence can only originate from forces (such as radiation pressure or hydrostatic pressure caused by convective processes) capable of acting on large masses of material. Velocities exceeding the velocity of thermal agitation can probably be originated by irregular bursts of radiation pressure.

The writer would emphasize that there are at least two distinct methods of approach to theoretical problems of the above character. One is to attempt to represent mathematically, as accurately as possible, the probable state of affairs in the sun, and to elucidate the theoretical consequences to be expected. The results of this method are in form immediately available for the observer. The other is to study the abstract properties of idealized systems with the object of throwing light on and gaining insight into the actual processes going on. Since our ultimate aim is to gain an understanding of the phenomena and their simplest possible physical description (or explanation, if this term be preferred) the second method will in general lead to more permanent gain than the former. Explanation in principle will survive when "photographic" representations become obsolete owing to the improvement of data.

D. H. Menzel:

1. There is need for further precise photometric data on the intensities and profiles of the lines in the chromosphere. The observations should be made with instruments of high dispersion, preferably at times of total eclipse. The Lick Observatory plates indicated that there was an increase in width of the lines with chromospheric height. Furthermore, the width was greater for the helium than for the metallic lines. This requires further checking.

2. The suggestion has been made that there is some relation between the individual faculae and the tiny chromospheric spikes that form the solar atmosphere. It might be possible to check this, though observations would be difficult.

3. There is also the possibility, almost the probability, that there is a direct relation between the faculae and the granulations that are so prominent upon spectroheliograms taken in hydrogen light.

4. It would be interesting and important to know how rapidly changes take place in the smaller chromospheric spikes. Marked changes in the form of the larger eruptive prominences occur within only a few minutes. Do the tiny spikes change as rapidly, or do they persist over a period of some days?

5. A study of the forms of the same prominence in lines of different elements and in lines of the same element but of different stages of ionization and excitation should do much to unravel the problems of the source of excitation and the cause of the levitation of the prominences. For example, it is certain that the lines of helium are much stronger in the prominences, relative to the metallic lines, than in the lower chromosphere. This is probably an extreme case of what is a very general law governing the intensities of lines in the solar atmosphere. The indications are that it is related to the effect discovered in stellar atmospheres by Russell, Adams

and Miss Moore, and termed "Deviation of the atmosphere from thermodynamic equilibrium."

6. It should be possible to obtain a spectroheliogram of the sun in light of the line 3905, Silicon. This line is of special interest because it is the only strong line, except those of hydrogen, that has a fairly high excitation potential.

7. There is need for precise determinations of wave-lengths of flash-spectrum lines. These should be done with an interferometer at time of eclipse. Incidentally, the interferometer could be used in determining the profiles of the lines at the same time. These would be of value in the following specific problems: The Einstein shift, St John's ascending and descending currents, turbulence, self-reversal as influenced by anomalous dispersion, Stark Effect.

8. Various observers have reported, from time to time, variations in the height of the chromosphere. It is not improbable that the chromosphere does vary both in height and intensity. In my opinion, however, most of the observations upon which this conclusion was based were greatly affected by systematic error. Homogeneous material, freed from all effects of atmospheric seeing, focus and other instrumental difficulties, and based upon a precise definition of the phrase, "Height of the chromosphere," is greatly to be desired. Heights obtained from objective-prism spectrograms of the sun at time of eclipse showing the crescents must be carefully derived in order to remove systematic errors that enter from the serrated edge of the moon.

9. It should be possible to detect and measure, with a radiometer or similar device, the higher members of the Paschen series of hydrogen on the chromosphere at the time of eclipse.

Charlotte E. Moore:

With the aid of the excellent high dispersion photographs of the sun-spot spectrum taken with the 150-foot tower telescope and 75-foot spectrograph on Mount Wilson, spot intensities have been estimated on the Rowland scale for 6312 lines of atomic origin. A quantitative study of the composition of the atmosphere above sun-spots based on the calibration of the Rowland intensity scale has given the following results. Taking T, the solar temperature, as 5740° K., T′, the spot temperature, is equal to $4720 \pm 40°$ K. The ratio of electron pressures, Pe′ (spot)/Pe (disc), equals $0{\cdot}60 \pm 0{\cdot}10$.

The "level of ionization" as defined by Russell is the ionization potential of an atom which would be just 50 per cent. ionized under given conditions. For the spot this level is 7·0 as compared with 8·5 for the disc. From these quantities the percentages of ionization for disc and spot were calculated for 28 elements. By means of these percentages and the calibration of the Rowland intensity scale mentioned above, the ratio of the amount of material above the spot to that above the disc was determined as equal to $1{\cdot}70 \pm 0{\cdot}11$.

As a result of this work several problems for future investigation have suggested themselves. Seven spots were used in taking the plates on which the quantitative study of the sun-spot spectrum is based. It is very desirable to have the entire spectrum from violet to red photographed with one spot and also with different times of exposure. It would then be possible to study the effect of different spots on the estimated spot intensities mentioned above and correct an error due to this cause if one exists.

A study of the magnetic field due to different spots and in different regions photographed with the same spot offers an interesting field for enquiry.

Photographs of the real spot spectrum in the violet and also in the infra-red would be of vast assistance in continuing investigations on the physical conditions existing in sun-spots.

Finally, it is hoped that the difficult problem of explaining the exceptional strengthening of faint solar lines in the spot spectrum may be solved when better and more extensive spot material is available.

An extensive "multiplet table of astrophysical importance" will soon be completed. An attempt has been made to list, by elements, all lines of known multiplet designation which might be useful in a detailed investigation of solar, spot or stellar spectra in general. Multiplets of elements important in early type stars are included, but the table consists primarily of solar multiplets. The whole number of lines included is about 10,000.

With the aid of this collection the identifications of the solar lines have been revised and extended. It is hoped that this work will be of use in carrying out an extensive programme on the photometry of solar lines. An absolute calibration of Rowland intensity scale based on lines of various intensities, which are free from blends, is urgently needed.

The Hydrocarbon Bands in the Solar Spectrum. R. S. Richardson:

The hydrocarbon band at $\lambda 4300$, known to astrophysicists as Fraunhofer's G band, is the strongest in the visible region of the solar spectrum. For this reason it was selected to study in detail conditions affecting the production of molecular spectra in sun-spots and the reversing layer. The two principal investigations undertaken were: (1) the determination of the temperature gradient in the reversing layer, and (2) the calculation of the relative pressure in sun-spots and the reversing layer.

(1) The basis for the determination of the temperature gradient in the reversing layer is the fact that if the temperature of an emitting gas is not homogeneous, the intensities of the band lines show for the higher rotational energy levels a higher temperature than for the lower ones. Prof. Birge, referring to the intensities of the band lines, says: "Obviously, if the actual intensity curve is the sum of two or more true curves, for different temperatures, the resulting curve in case of large quantum numbers will be chiefly the result of the highest temperature involved, for the lower temperatures will contribute practically nothing to it. Similarly, the lower quantum number region will be mainly given by the lowest temperature involved." Therefore, the difference between the temperatures determined from the higher and lower quantum numbers should give the temperature gradient in the gas layer, if the depth of the layer can be found.

An examination of the solar spectrum from $\lambda 4250$ to $\lambda 4400$ showed that enough lines were unobscured in the P branch of the G band to determine the intensity throughout the entire series. Plates were taken of these lines in the third order of the 75-foot spectrograph at Mount Wilson. The linear scale is 1 A = 4·8 mm. The plates were calibrated by taking successive exposures on the centre of the sun through a rotating sector. Microphotometer tracings were made of the lines selected, and the central intensities measured as percentages of the intensity of the continuous background.

The temperatures obtained from the intensities of the lines are:

$$\begin{aligned} T\ (\text{minimum}) &= 4430^\circ \pm 160^\circ\ \text{K}. \\ T\ (\text{maximum}) &= 6080^\circ \pm 130^\circ\ \text{K}. \\ T\ (\text{mean}) &= 5080^\circ \pm 120^\circ\ \text{K}. \end{aligned}$$

These temperatures indicate that there is a difference of 1650° between the highest and lowest levels in the reversing layer at which the CH molecules can exist in any quantity. Using data by St John and Babcock, the temperature gradient in this region comes out about 13° per km.

(2) A formula was developed from the theory of band line intensities and the equation of dissociation equilibrium for molecules, by means of which the relative pressure in sun-spots and the reversing layer could be calculated. The unknown quantities in this formula are the intensities of the lines in the spot and disc, and the temperatures of the spot and disc.

An inspection of the best spot spectrograms at Mount Wilson showed that unobscured lines in the G band have practically the same intensity in the spot and disc. Using this result, and taking T (spot) = 4750°, T (disc) = 5080°, the ratio of the pressures

$$\frac{P_C + P_H + P_{CH}) \text{ spot}}{(P_C + P_H + P_{CH}) \text{ disc}} = 0{\cdot}49,$$

where P_C = partial pressure of carbon atoms;
P_H = partial pressure of hydrogen atoms;
P_{CH} = partial pressure of hydrocarbon molecules.

Petrie has derived formulae by means of which the ratio of the total pressure in the spot and disc can be found. Using T (disc) = 6000°, T (spot) = 4750°, Petrie's formulae gives the result:

$$\frac{P_{\text{spot}}}{P_{\text{disc}}} = 0{\cdot}88.$$

Miss Charlotte Moore has recently published a paper in which she determined the relative electron pressure in the spot and disc as 0·60.

So far as the author is aware, these are the only determinations that have been made of the relative pressure in sun-spots and the reversing layer. A closer agreement can hardly be expected, considering that the relative pressure in each case refers to a different substance.

13. *Subventions.*

Grants of £60 and of £125 a year for three years were made in 1928 to the observatories at Arcetri and Meudon. For the next triennium the requests are $300 a year for Arcetri and 15,500 francs = $600 a year for Meudon. Of the use made of the grant to Arcetri Dr Abetti says:

The grant of £60 per year, together with additional financial help from the Zürich and Arcetri Observatories, has been devoted to the publication of the *Immagini Spettroscopiche del Bordo Solare* for another four years, namely from 1925 to 1928. Copies of these publications have been sent to the more important institutions and observatories in the world. Owing to the depreciation of the pound, the increase in the number of observatories, which contribute to the *Immagini*, and also to the great activity of the sun in the years 1926 to 1928, necessitating a larger number of tables, it has not been possible, as it was hoped, to begin the publication of the *Immagini* for the period 1911–22. These are still missing.

In urging that the grant of $300, corresponding to £60 (gold pounds) per year to the Arcetri Observatory should be continued for the next three years I am supported by the members of our Committee: Messrs Brunner, Favaro and Jimenez. If this is

https://doi.org/10.1017/S0251107X00016412 Published online by Cambridge University Press

sanctioned it will be possible to continue the publication of the *Immagini* from 1929 up to date.

Of the grant to Meudon M. Esclangon says:

Les trois premières séries de cartes, se rapportant aux observations effectuées en 1919–1920–1921, ont été publiées en trois fascicules, au cours de l'année 1928, à l'aide d'une subvention de £100 par an, accordée pour trois ans par le deuxième Congrès de l'Union (1925). Sur notre demande, le Congrès suivant a porté la subvention annuelle à £125, pour une nouvelle période de trois ans, afin de faciliter, au cours de cette période, la mise à jour de la publication. Un quatrième fascicule, relatif aux années 1922–1923–1924, a été publié en 1930 et un cinquième, comprenant les années 1925–1926–1927, en 1931. Le fascicule suivant est en préparation et sera vraisemblablement achevé à la fin de 1932. A ce moment, la mise à jour sera à peu près réalisée. Il sera possible, par la suite, de publier, à la fin de chaque année, les cartes se rapportant aux phénomènes observés l'année précédente.

Les dépenses effectuées pour la rémunération de l'assistant chargé des mesures et des dessins préparatoires à la construction des cartes, ainsi que pour l'impression de l'ouvrage, ont été, depuis l'origine de la publication, notablement supérieures à ce qui avait été prévu. Elles seront moindres dans l'avenir, lorsque la mise à jour sera achevée, mais dépasseront encore de beaucoup le taux de la subvention annuelle la plus élevée accordée jusqu'ici.

Il serait donc très important que cette subvention soit maintenue à la valeur qu'elle avait pour nous en 1928, soit 15,500 francs.

C. E. St John
President of the Commission

https://doi.org/10.1017/S0251107X00016412 Published online by Cambridge University Press