

## 12. COMMISSION DE LA RADIATION SOLAIRE ET DE LA SPECTROSCOPIE SOLAIRE

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MEMBRES: MM. Abbot, Babcock, P. Carrasco, Carroll, S. Chapman, d'Azambuja, Dingle, Evershed, Lyot, Menzel, Milne, Minnaert, Pannekoek, Perepelkin, Pettit, H. H. Plaskett, Russell, Sekiguti, Shane, Mme Moore Sitterly, MM. Stetson, ten Bruggencate, Unsöld, Woolley, Yü.

The Commission has suffered the heavy loss of Prof. W. Bernheimer, who was co-opted on to our Commission and whose work is well known and appreciated.

The following report touches the subjects of interest to this Commission as treated by the various members and is not an account more or less complete of the work done in them in the three years.

### SOLAR RADIATION

Report of *Abbot* on the solar constant work of the Smithsonian Institution:

In 1923, hoping to abbreviate the process of determining the solar constant so as to have five observations computed per day instead of two, I devised a very short method of computation based upon the extensive use of tables. About a year ago, it suddenly occurred to me that there was a flaw in this method which would take considerable space to explain but which was of this nature: The variation of the sun could indeed be shown, but only that fraction of it which affects the reading of the pyrheliometer. That fraction is less on hazy days and at poor stations than on excellent days at good stations. The consequence is that in the solar constant values reported in Volume 5 of the *Annals of the Astrophysical Observatory* and in occasional papers since 1930, all results since 1923, while they indeed show the variation of the sun in the proper phase, show it on the average of only about  $\frac{1}{2}$  of the true amplitude. Moreover, results of the several stations are caused to differ because of the unequal effects of this source of error as between clear and hazy conditions.

During the past year, my colleagues Messrs Aldrich and Hoover, with the aid of numerous computers, have been re-reducing the solar constant values observed since 1923 at our several stations. The work is about half finished, and it is hoped that a complete and homogeneous series of the daily solar constant values will be available by the latter part of 1938.

Nearly two years ago I published two papers entitled "The Dependence of Terrestrial Temperatures on the Variations of the Sun's Radiation" (*Smithsonian Miscellaneous Collections*, 95, No. 12) and "Further Evidence on the Dependence of Terrestrial Temperatures on the Variations of Solar Radiation" (*Smithsonian Miscellaneous Collections*, 95, No. 15), which seemed to me to prove definitely that the daily variations of the sun are of importance for weather conditions and that an exact knowledge of them might enable forecasts of weather to be made two weeks in advance. These results were shown to Messrs W. R. Gregg, R. A. Millikan, K. T. Compton, and Isaiah Bowman, with the result that they joined in a memorandum expressing their interest in these disclosures. With this assistance a measure was approved in the United States Senate appropriating \$200,000 to establish seven additional stations for solar constant observation. This measure failed of

confirmation in the House of Representatives, and it has not since been possible to revive it.

In the hope, however, of obtaining solar data which could be used for the object of long-range weather forecasting, I have made a small grant to Dr Brian O'Brien, of the University of Rochester, who has developed ingenious apparatus capable of measuring the intensity of a narrow band in the ultra-violet spectrum from free balloons carried to 20,000 metres and with their records automatically transmitted to the ground station by short-wave radio. The accuracy of the observations is somewhat better than 2 per cent., so that it is hoped that it may be sufficient to follow the variation of the sun in the far ultra-violet where the percentage of solar variation is supposed to be ten or twenty times as great as that of the solar constant. It is expected to make about fifty balloon flights next summer to compare their results with the solar constant observations at Montezuma, Chile.

For lack of continued support, and owing to the frequent illness of observers whenever they have had occasion to visit Cairo, the station at Mount St Katherine on the Sinai Peninsula of Egypt was discontinued as from December 1, 1937.

It may be of interest to know that I have developed a solar flash boiler capable of making steam within less than five minutes and operated automatically to maintain a constant pressure of steam whenever the sun shines. Its efficiency is sufficient to convert 15 per cent. of the solar energy at the mirror into mechanical work.

#### Report of *Stetson*:

With the co-operation of others I have now over ten years' records of radio reception automatically recorded, which is serving as a basis for investigation of the effect of change in solar radiation with the sunspot cycle upon the ionization of the upper atmosphere, concerning which I have made numerous reports at various places from time to time.

It seems to me very important that the present daily solar observations, carried on through international co-operation, should include as soon as possible quantitative records of solar radiation through the entire spectrum. The valuable but sometimes conflicting measurements which have been made at Mount Wilson and elsewhere of the intensity of the ultra-violet have yielded sufficiently valuable information to make it seem worth while to institute a co-operative effort to get daily records throughout a broader region of the spectrum than the transmission of silver and the transmission of gold alloy. If daily photographs of the sunlight were to be made with a quartz spectrograph on photometrically standardized plates, it seems to me that a wealth of material would be available for studying the distributions of radiation and any possible changes throughout the whole solar cycle.

I am at present working on the design of a device which would automatically record through the use of a photoelectric cell the distribution of sunlight as registered through a series of filters covering broad bands of the spectrum. This is perhaps a simpler but on the whole less satisfactory method of attacking the problem than the examination of daily spectra.

The argument that variable absorption in the earth's atmosphere seriously complicates the interpretation of distribution of sunlight is of course a sound one, and yet it appears not unreasonable that modification in our own atmosphere, as, for example, the amount of ozone, is itself accompanied by changes in the intensity of solar radiation, particularly in the region of short wave-lengths.

I have read with much interest the last report printed in the *Transactions of the I.A.U.* concerning the work of Commission 12 and particularly Minnaert's report concerning the study of the variability of Fraunhofer lines, a subject in which I have long been interested. This field demands every encouragement on the part of Commission 12. Any real variation in, say, the solar or telluric lines with the sun-spot cycle would appear to be of great significance.

In closing, I should like to call attention to some recent work by Adel and Lampland at the Lowell Observatory which they have just reported to Section D of the American Association for the Advancement of Science. This pertains to the discovery of nitrogen pentoxide through the identification of a band at  $7.6 \text{ m}\mu$ . on the edge of the broad absorption band of water vapour. This appears to be definitely associated with the ozone layer, and variations in its intensity may yet prove an important indicator of variations in the ionization of the upper atmosphere. Since the  $\text{N}_2\text{O}_5$  molecule is apparently less stable than even  $\text{O}_3$ , we may have here a criterion for measuring small variations in the ultra-violet light of the sun. I might remark that the discovery was due not only to the painstaking care and ingenuity of the workers at the Lowell Observatory but also to the favourable location of Flagstaff on account of the dry atmosphere. Even on moist days there the  $\text{N}_2\text{O}_5$  band is completely lost in that of the water vapour. The identification of the band by the Lowell observers was made possible through the recent researches of Hettner, Pohlman and Schumacher, who discovered this band of  $\text{N}_2\text{O}_5$  in the laboratory in a study of the spectrum of ozone. (See *Zeits. f. Physik*, **91**, 372, 1934.)

## SOLAR SPECTROSCOPY

### Report of *Babcock*:

*Calibration of Intensities.* The intensities given in the Revision of Rowland's Table are essentially unchanged from those stated by Rowland. It is well known that these are the eye-estimates of Jewell made from Rowland's spectrograms of more or less integrated sunlight with 21-foot concave gratings. Probably Jewell and Rowland thought of these numbers mainly as a descriptive key to be used in finding on the spectrograms the lines listed in the *Table of Wave-Lengths*. It is important to observe, nevertheless, that these intensities have been found to be statistically significant even when applied to spectrograms made with more powerful instruments with light from greatly restricted areas in large images of the sun.

Among other attempts to transform the arbitrary scale of Rowland's intensities into one having specific physical meaning the unpublished work of St John, Nicholson and Miss Ware at Mount Wilson may be mentioned. Their measurements reveal both accidental and systematic errors in Rowland's scale but, except for a few individual lines, these are not of surprising magnitude when the implications already mentioned are considered. In general their results are in fair agreement with those of other observers, but the discussion of such differences as appear must await publication of their data.

Among selected spectral regions from violet to red they have given special attention to the green-yellow. Here they included 254 lines of Rowland intensity 0 to 5 and observed both the quiet centre of a 43 cm. solar image and a region 3 mm. in from the limb for the same lines.

In the table the results of Allen and of Mulders are summarized in comparison

with the unpublished Mount Wilson data. The general agreement in finding a higher ratio between Rowland's lines of intensity 1 and 0 than between the next stronger adjacent intensities is clearly shown. Analysis shows that this could be explained by supposing that Jewell systematically included with his 0 lines too many that should have been described as -1. But it should be kept in mind that instrumental limitations both in the spectrographs and the microphotometers tend toward making the fainter lines too faint and could thus contribute to such a result.

Both centre and limb spectra show that the progressive change with wave-length of the total absorption of lines described alike by Rowland is sharply increased near  $\lambda$  5700. At this point in the spectrum a notable change in the Rowland intensity scale appeared abruptly, as shown by Allen's data, by the Mount Wilson measurements, and, with less appearance of discontinuity, by the earlier results of Mulders. It is interesting to note that in this spectral region Rowland resorted to the first-order spectrum, after using second and third orders for shorter wave-lengths.

Comparison of the Mount Wilson results for centre and limb spectra is particularly interesting, since the same lines and technique were used. Lines of intensity 3 and 1 between  $\lambda$  5400 and  $\lambda$  5900 consistently show about 10 per cent. greater total absorption near the limb, but the stronger lines average about 3 per cent. less, a quantity near the limit of reliability. When central intensities are compared, however, they are found uniformly about 10 per cent. higher at the limb than at the centre for such lines of intensity 0 to 5.

#### $\lambda$ 5400- $\lambda$ 5900, Centre of Solar Disk

Mt Wilson	Rowland Intensities 0 to 5 Allen*	Mulders†
Average decrease of total absorption, for lines described alike by Jewell, corresponding to 100 A. increase in wave-length.		
19 per cent.	20 per cent.	—
Average increase of total absorption per intensity unit, 0 to 5.		
43 per cent.	47 per cent.	38 per cent.
Increase of total absorption from 0 to 1.		
86 per cent.	78 per cent.	62 per cent.
Average increase of total absorption per unit, from 1 to 5.		
32 per cent.	38 per cent.	32 per cent.

\* *Memoirs Commonwealth Solar Observatory*, No. 5, Part 2, 1934.

† *Aequivalente Breedten van Fraunhoferlijnen in het Zonnenspectrum*, 1934.

Allen\* has studied the effect of scattered light in the spectrograph by measuring lines in the bands of atmospheric oxygen. From such observations at three points in the spectrum he has derived corrections to be applied to the measurements of adjacent solar lines. Comparison of the corrected absorption of solar lines on the same spectrograms† with the visually estimated intensities, not all of which are final, shows fairly satisfactory consistency in the latter, between  $\lambda$  6200 and  $\lambda$  7800, as determined by Miss Moore.‡ Further work by Allen§ from  $\lambda$  8880 to

\* *Mt Wilson Contr.* No. 566; *Ap. J.* **85**, 156, 1937.

† Allen, *Mt Wilson Contr.* No. 567; *Ap. J.* **85**, 165, 1937.

‡ Unpublished.

§ In press.

$\lambda$  11,600 illustrates the well-known difficulties of spectrophotometry in this region and shows that, in spite of these, useful data are now within reach. It is gratifying to find that Miss Moore's eye-estimates of intensity in the infra-red are not only linearly related to the measured absorptions of the lines, from  $-2$  to  $12$ , but are practically coincident with her scale at  $\lambda$  6900. For lines of intensity 5 and less the agreement with the scales at  $\lambda$  7800 and  $\lambda$  6200 is also reasonably close, but for stronger lines a considerable systematic difference in Rowland's intensities appears in the  $\lambda$  6200 region.

Mulders has photographed the solar spectrum from  $\lambda$  3600 to  $\lambda$  6900 in the second order of the 75-foot spectrograph, and from  $\lambda$  6600 to  $\lambda$  8900 in the first order, on calibrated plates. These are now being measured and reduced at Utrecht.

*Spectrum of the Reversing Layer.* The investigation of the solar spectrum from  $\lambda$  6600 to  $\lambda$  13,500 by Babcock and Miss Moore is still in progress, its publication having been delayed by unforeseen interruptions. A comparatively small number of spectrograms have still to be obtained and measured. Many minor details await completion.

The fundamental series of Mg lines has been discovered in the solar spectrum, before its detection in the laboratory, while the corresponding series for Na has lately been established in the sun through the use of Sawyer's improved laboratory data. The first member of the principal series of Li,  $\lambda$  6707, long recognized in the spot spectrum, has now been found in the spectrum of the disk. Although weak and diffuse, it corresponds so closely in position and fine structure with the laboratory line as to leave little doubt of the identity.

*Spectra of Sunspots.* Nicholson has obtained spot spectra in the infra-red to about  $\lambda$  9000 and is continuing this series as opportunity affords. An interesting group of unidentified spot lines has been found near  $\lambda$  8715 on these plates. The lines appear to have Zeeman patterns of opposite sign to those shown by atomic lines on the same plates and the separations are much smaller. They are probably of molecular origin.

*Chromospheric Spectrum.* Nicholson and Richardson are studying the spectra of bright chromospheric eruptions. A recent addition to their equipment is a concave grating spectrograph, free of astigmatism, giving a dispersion of about 8 A./mm. and requiring only very short exposures. They have found that the intensity of radiation in the line H $\alpha$  observed in a bright eruption may exceed twice that in the adjacent continuous spectrum.

The spectrum of the chromosphere, observed at the limb of the sun without eclipse, has been studied at Mount Wilson by Horace Babcock in the visible and photographic infra-red. Between  $\lambda$  6740 and  $\lambda$  11,653 he has measured about 200 emission lines, among which the first triplet in the principal series of He,  $\lambda$  10,830, is outstanding. The Paschen series of H are present from  $\lambda$  10,938 to  $\lambda$  8467 inclusive, except  $\lambda$  9229 and  $\lambda$  9546 which are obscured by atmospheric water vapour. The forbidden line O $^+$  at  $\lambda$  7325 is seen and a number of lines due to Fe, Fe $^+$ , Mg, and some other elements, are identified.

*Spectrum of the Corona.* At the eclipse of June 8, 1937, Dunham obtained a spectrum of the corona showing a faint line not previously recognized. Its wavelength is approximately  $\lambda$  4312.

*Solar Rotation.* The extensive spectroscopic measurements of the solar rotation carried out by St John have been continued by Nicholson, Richardson and E. F. Adams. Special attention has been given by them to possible causes of systematic error and two effects have been observed, both of which tend to make the apparent

rotational velocity slightly too small. One of these is the combined effect of the scattering of light in the atmosphere, in the observing telescope, and in accessories above the slit, which mixes, in the slit of the spectrograph, a small amount of undesired light with that selected from the solar image for observation. The other is a lateral spreading or scattering of light in the spectrograph when spectra from opposite limbs are in too close proximity on the photographic plate. This is probably a true diffraction of light, unusually conspicuous here because of the great ratio, about 400 : 1, between the focal length of the spectrograph and the length of the ruled grooves on the grating.

It appears that earlier measurements made with the 150-foot tower equipment should be increased about 4 per cent. The agreement between results from the spectroscopic method and those derived from the rotational displacement of visible details on the sun is thus improved.

*Limb Effect.* Babcock has measured\* for over 500 lines the apparent change in wave-length between the centre of the solar disk and a point 0.98 of the radius from the centre on an image about 17 cm. in diameter. The wave-lengths lie between  $\lambda$  5100 and  $\lambda$  6400 and most of the intensities between 0 and 8. On the average the wave-lengths near the limb exceed those at the centre by 0.0053 A. There is evidence of an increase in the observed displacement with the wave-length and possibly also with the intensity. Attempts to reduce the Rowland intensities of these lines to homogeneity by means of calibration curves indicate that the dependence on wave-length would be moderately increased.

Report of Mrs Moore Sitterly:

*Multiplet Table of Astrophysical Interest.* A revised edition of this table is being prepared. It is hoped that both laboratory and solar wave-lengths can be included in the new edition.

Recent work on the analysis of V II,† Cr I, Cr II,‡ Fe II,§ and Co I|| has provided important new material for the identification of solar and stellar lines. The multiplets of these elements will be extensively revised in the new Table.

With the aid of work by Burns¶ Sn and Ta may now be added to the elements present in the solar spectrum. The number 61 reported in 1937 to be present\*\* may consequently be extended to 63. In addition, Burns reports the presence of Cs, which was previously omitted because of insufficient solar data. On the best existing photographs of the sunspot spectrum taken at Mount Wilson there appears to be a faint spot line close to the position of the ultimate Cs line at  $\lambda$  8521.10, but the background is confused by the presence of band lines. It is hoped that adequate photographs can be secured during the present sunspot maximum, in order to settle this important question.

Identifications of solar lines are continually being revised and extended with the aid of new multiplet material. The progress in spectrum analysis since 1935 has made it possible to identify many more lines accurately, both from observed laboratory wave-lengths and from predicted values derived from the spectroscopic terms. It is hoped that arc and spark spectra of Tb, Th and Ho may be more

\* Unpublished.

† Analysis based on unpublished material by W. F. Meggers.

‡ Unpublished work by C. C. Kiess.

§ Unpublished work by J. C. Dobbie.

|| Unpublished work by H. N. Russell and R. B. King.

¶ Presented at the meeting of the A.A.S., December 1937.

\*\* C. E. Moore, *Mt Wilson Contr.* No. 565; *Ap. J.* 85, 79, 1937.

completely observed in the laboratory, in order that the question of the presence of the ultimate lines in the solar spectrum may be settled.

*Infra-red spectrum.* Babcock and Mrs Moore Sitterly are continuing their study of the infra-red solar spectrum. The standards of wave-length have been discussed in detail in a Mount Wilson Contribution\* and also in the Report of Commission 14. The  $3^2D-^2F^{\circ}$  series of Na has been measured in the laboratory by Sawyer and Rood, and reported by them as probably present in the sun.† The leading member  $\lambda 18,459$  is beyond the red limit measured by Babcock. The second member  $\lambda 12,679.0$  probably contributes to a strong hazy solar line at  $\lambda 12,680.40$ ; intensity  $6N$ . The next two lines,  $\lambda 10,834.4$  and  $\lambda 9961.0$ , give sun minus laboratory residuals of  $-0.4$  and  $+0.4$  respectively with solar lines of intensities 5 and 0. The last four members are probably very faint if present. One coincides with a line of intensity  $-3(?)$ , and three are blended or masked in the solar spectrum.

More than 400 extremely faint new lines have been measured in the solar spectrum on one set of plates taken at Mount Wilson in the region  $\lambda 6600$  and  $\lambda 7330$ : the overlap between the Revised Rowland Table and Babcock's measures in the infra-red. The reality of these lines will be checked on plates taken with a different grating.

#### Report of Minnaert:

A *Photometric Atlas of the solar spectrum* will soon be published by the Observatory at Utrecht. The plates have been taken by Mulders at Mount Wilson, in the second order of the big tower telescope.

The whole collection of about 120 plates gives a complete picture of the solar spectrum between 3600 and 8800 Å. with a dispersion of 3 Å./mm. All these plates have an exact photometric standardization, by means of a step reducer. We have taken at Utrecht plates for the extreme UV and IR, which of course are much less beautiful, but which add also the region 3300–3600 and 8800–10,800. All these plates have now been measured at Utrecht with the Moll microphotometer, to which a special auxiliary apparatus has been fitted, so that it records at once the real intensity instead of the transmission of the plate. The description of this apparatus has just been sent for publication in the *Zeits. f. Astroph.* The record will consist of about 360 curves, each 35 cm.  $\times$  10 cm. The scale is 2 cm./Å. The reproduction technique has been carefully selected. The registration will probably be ready by 1 August. Specimens of the reproduction will be shown at the meeting in Stockholm.

About the other work done at Utrecht I may mention: first an investigation by Mr J. R. van den Briel and myself of the possible existence of absorption discontinuities in the solar spectrum. My preliminary work on that subject had shown that strong discontinuities near the limit of the magnesium series, though to be expected according to Biermann, could not be found in the solar spectrum. This time we made a search for discontinuities at the end of the sodium series near  $\lambda 4080$ , where, in view of Pannekoek's absorption coefficient, we expected a discontinuity. We made a theoretical calculation on the jump in the intensity to be expected at the centre of the sun, and at the limb, and we found that these jumps ought to be very easily observable. Nevertheless, not the slightest indication of such discontinuities was found. These observations have to be explained probably

\* Babcock, Moore and Hoge, *Mt Wilson Contr.* No. 534; *Ap. J.* 83, 103, 1936.

† Unpublished material, University of Michigan.

by the disappearance of high orbits in the atom, under the influence of perturbing electric fields.

Another investigation has been made by Mr J. Houtgast, who measured the complete profiles of twenty Fraunhofer lines, each at six different distances from the sun's centre. A comparison between his results and those of some other observers shows that the general trend of the curves is similar for all of them but that there remain great divergences between the individual results. I think that an elucidation of the errors made in this kind of measurement is very important for solar physics and that the whole subject of the variation of the profile over the disk is one of the main points to be investigated in future.

#### Report of *ten Bruggencate*:

Am Institut für Sonnenphysik in Potsdam, das ich seit 1935 leite, wurde die Bearbeitung zweier Hauptprobleme der Sonnenphysik in Angriff genommen: (1) Messung von Linienprofilen ausgewählter Fraunhoferlinien (*ten Bruggencate*, von Klüber) und (2) Untersuchung der Sonnengranulation (*ten Bruggencate*, Grotrian, von der Pahlen).

*Linienprofile.* Wir streben eine möglichst exakte Vermessung der Profile einzelner, ausgewählter Fraunhoferlinien an. Zur Vermeidung von Streulicht im Hauptspektrographen wurden alle Beobachtungen stets unter Verwendung eines spektralen Vorzerlegers, der den speziellen Verhältnissen des Turmteleskops und der Spektrographen (Plangitter oder Prismen) angepasst ist, durchgeführt. Der Einfluss des endlichen Auflösungsvermögens des Spektrographen auf die Linienkontur wird empirisch bestimmt. Die Apparatekontur wird aus den Emissionslinien einer Krypton-Röhre abgeleitet. Um sicher zu gehen, dass die Kr-Linien bei einem Auflösungsvermögen von rund 100 000 wirklich die reine Apparatekontur liefern, haben wir als Kontrolllichtquelle eine mit Yttrium gefüllte, in flüssige Luft eingetauchte Schülersche Hohlkathodenröhre benutzt. Die Entladung brennt in strömendem Argon als Füllgas. Yttrium wurde gewählt, weil Prof. Schüler bei seinen Untersuchungen mit Etalons grossen Auflösungsvermögens bei den von uns benutzten Linien keine Hyperfeinstruktur nachweisen konnte. Es stellte sich dabei heraus, dass bei einem Auflösungsvermögen von rund 100 000 die Kontur der Y-Linien mit der der Kr-Linien einer ungekühlten Kr-Röhre übereinstimmt. Dagegen waren die in der Schüler-Röhre auch auftretenden Argon-Linien ein wenig breiter als die Y-Linien. Die Verwendung von Ar- oder Ne-Röhren zur Bestimmung der Apparatekontur eines Spektrographen mit einem Auflösungsvermögen von rund 100 000 ist also nicht ohne nähere Nachprüfung statthaft.

Bei der Neujustierung des grossen Prismenspektrographen des Turmteleskops sind wir bei der Durchführung von Intensitätsmessungen auf grosse Schwierigkeiten gestossen, die auf kleine Inhomogenitäten der grossen Glasmasse und auf Flächenfehler zurückzuführen sind. Wir haben dabei den Eindruck gewonnen, dass Prismenspektrographen von den Dimensionen des Potsdamer Spektrographen (Glasweg an der Basis bei Autokollimation  $\sim 100$  cm.) sich nur nach sorgfältigen Voruntersuchungen und eventueller Lokalretusche der Prismenflächen für Intensitätsmessungen eignen.

Das grosse Andersonsche Plangitter des Instituts zeichnet sich durch gute Linienqualität in der zweiten Ordnung und durch die Schwäche seiner Geister aus. Trotzdem ist es für Restintensitätsmessungen nur brauchbar unter Verwendung eines Vorzerlegers, dessen Ausblendespalt so eng gestellt werden muss, dass nur ein Wellenlängenbereich  $\Delta\lambda/2$  hindurchgelassen wird, wo  $\Delta\lambda$  den Abstand von der



Hauptlinie bis zum Geist erster Ordnung bedeutet. Beim Andersonschen Gitter ist in der 2. Ordnung  $\Delta\lambda/2 \sim 4$  A.E.

Die photometrische Kalibrierung der photographischen Platten erfolgt mit einem Standardisierungsspektrographen unter Verwendung eines Platinstufenfilters. Das Filter wird automatisch vor dem Spalt parallel zu den Stufen hin- und hergefahren zum Ausgleich von Durchlässigkeitsschwankungen innerhalb der einzelnen Stufen. Das Filter wird mit Hilfe des Abstandsgesetzes geeicht unter den gleichen Bedingungen, unter denen es bei der Standardisierung gebraucht wird. Der Spalt des Spektrographen bleibt ein für allemal fest eingestellt.

Für künftige Untersuchungen über Linienprofile möchten wir auf den Vorschlag der Kommission bei der Pariser Tagung zurückgreifen, dass wenige ausgewählte Linien in verschiedenen Spektralgebieten an einigen Observatorien möglichst exakt vermessen und miteinander verglichen werden. Man sollte anstreben, dass diese Standardlinien dann von anderen, weniger gut ausgestatteten Instituten zu Eichungszwecken benutzt werden können. Jedem neu auf dem Gebiet der Linienprofile arbeitenden Astrophysiker wäre dadurch eine einfache Prüfung der Leistungsfähigkeit seiner Apparatur möglich und es würden ihm umfangreiche Voruntersuchungen erspart bleiben. Das Institut für Sonnenphysik in Potsdam könnte sich an einer Vermessung von Linien in dem Gebiet  $\lambda$  6200–6300 A. beteiligen.\*

*Sonnengranulation.* Unsere Untersuchungen der Granulation haben wir im Sommer 1935 durch Simultanaufnahmen im Ultraviolett ( $\lambda_{\text{eff.}} = 3800$  A.) und im Infrarot ( $\lambda_{\text{eff.}} = 7100$  A.) begonnen. Es sollte zunächst die Übereinstimmung der Granulationsstruktur in den beiden Spektralbereichen geprüft werden. Durch Blinken simultaner Platten und unter Ausnutzung des Dreheffektes (s. ten Brugencate und Grotrian, *Zs. f. A $\phi$ h.* **12**, 323) konnte eine nahezu vollständige Übereinstimmung festgestellt werden.

Im Sommer 1936 wurden Serienaufnahmen der Granulation im Ultravioletten erhalten, die mit Hilfe einer neuen Methode zur Ableitung eines Wertes für die mittlere Lebensdauer der Granulation dienten. Was die Methode und das Ergebnis betrifft, so möchte ich auf die oben zitierte Arbeit verweisen.

In diesem Jahre haben wir den Versuch einer Photometrie der Granulation im Ultravioletten ( $\lambda_{\text{eff.}} = 3800$  A.) unternommen. Es handelt sich dabei um die Bestimmung des Mittelwertes der Helligkeitsschwankung auf der Sonnenoberfläche infolge der Granulation und seiner Abhängigkeit vom Abstand von der Sonnenmitte. Ein wesentliches Problem war die Elimination des Einflusses der Körnigkeit der photographischen Platten auf die Messungen. Sie erfolgt auf statistischem Wege. Eine weitere Schwierigkeit ist die einwandfreie Berücksichtigung des Umstands, dass der Photometerspalt bei Annäherung an den Sonnenrand infolge der perspektivischen Verzerrung eine zunehmende Zahl von Granulationsgebilden überdeckt. Die vorliegenden Resultate lassen erkennen, dass Randeffekte—wenn überhaupt—erst hart am Sonnenrand auftreten. Ein bei der Firma Zeiss bestelltes Negativ-System wird die effektive Brennweite des Turmteleskops verdoppeln, sodass die Untersuchungen in absehbarer Zeit an einem doppelt so grossen Sonnenbild wiederholt werden können. Eine Veröffentlichung der vorläufigen Resultate mit Beschreibung der befolgten Methode ist in Vorbereitung.

Eine Arbeit von grosser Wichtigkeit, die sich aber unter den Potsdamer Luftverhältnissen nur sehr schwer wird durchführen lassen, ist die Untersuchung von zeitlichen Veränderungen in der Struktur der Penumbra von Sonnenflecken. Es sollte möglich sein, aus solchen Beobachtungen einen Schluss zu ziehen auf einen

\* *Transactions of the International Astronomical Union*, **5**, 372, 1936.

eventuell vorhandenen Zusammenhang zwischen der Granulationsstruktur und der Filamentstruktur in der Penumbra.

Report of *Unsöld*:

Zur Zeit scheint es mir eine der wichtigsten und noch am wenigsten geklärten Fragen zu sein, welcher Anteil neben der Strahlungsdämpfung, der Stossdämpfung (*Zs. f. Ap.* **12**, 56, 1936) an der Bildung der starken Fraunhoferlinien zukommt. Messungen der Äquivalentbreiten von "langen" Multipletts u.s.w., die vom linearen in den Wurzel-Teil der Wachstumskurve hinüberreichen, könnten zur Klärung dieses Problems beitragen.

*Selbstabsorption in Protuberanzen.* Aus Beobachtungen von K. Schwarzschild (*Astr. Mitt. Göttingen*, 1905) über das Intensitätsverhältnis von  $\text{Ca}^+$ : Wasserstofflinien, sowie von M. Minnaert u. C. Slob (*Proc. Amst. Acad.* **33**, 65, 1930) über das Intensitätsverhältnis  $\text{H}\alpha$ :  $\text{HeD}_3$  in Protuberanzen muss man schliessen, dass die Selbstabsorption in  $\text{Ca}^+\text{H}$  und  $\text{K}$  stark, in  $\text{H}\alpha$  mässig, und in  $\text{HeD}_3$ ,  $\text{H}\beta$  und schwächeren Linien nicht vorhanden ist. Für  $\text{H}\alpha$  ist eine quantitative Bestimmung der Selbstabsorption möglich.

Die Beobachtungen von E. Pettit (*Ap. J.* **76**, 9, 1932) bzw. B. Lyot (*C.R.* **202**, 392, 1936) dass die "streamers" der Protuberanzen im Verhältnis zu deren Hauptmassen in  $\text{Ca}^+\text{H}$  und  $\text{K}$  am stärksten, in  $\text{H}\alpha$  schwächer und in  $\text{HeD}_3$  am schwächsten erscheinen, finden so (wie zum Teil auch Lyot selbst schon bemerkte) eine zwingende Erklärung ohne Annahme von selektiven Anregungs- oder Trennungseffekten.

*Streuung an freien Elektronen.* Im Spektralbereich  $\lambda$  5950–6400 hat B. Lyot in den Protuberanzen ein kontinuierliches Spektrum mit einem Polarisationsgrad von  $\sim 15\%$  beobachtet. Sowohl der Polarisationsgrad (nach S. Baumbach, *Astr. Nach.*, im Erscheinen), wie auch die Stärke des Kontinuums (schwächer als das Balmerkontinuum bei  $\lambda < 3647$ , stärker als das Paschenkontinuum  $3647 < \lambda < 8206$  des Wasserstoffs) werden durch die Annahme der Streuung an freien Elektronen quantitativ erklärt.

Für weitere theoretische Untersuchungen über die Protuberanzen wäre es sehr wichtig, ein ausgedehnteres Material an Linienintensitäten zu haben. Deren Interpretation dürfte einfacher sein als die der Chromosphärenlinien, da in schwächeren Protuberanzenlinien ( $< \text{H}\beta$ ) die Selbstabsorption unwesentlich wird.

*Dingle* will give at the meeting an account of the methods adopted on solar line-profile measurements and results obtained by the Department of Physics of the Imperial College of Science in London.

*H. H. Plaskett* reports on the work done at the University Observatory at Oxford: namely a study by himself of the surface brightness of solar granulation (*M.N.* **96**, 402, 1936) and a study of the behaviour of faint Fraunhofer lines towards the limb of the sun by Miss Adam (*M.N.* **98**, Dec. 1937). In addition, work has been continued on the determination of the surface brightness of the sun as a function of wave-length and position on the disk. The observational work on the first part of this investigation is complete; and at present they are engaged in the determination of transmission of filters and neutral tint wedges.

*Lyot* has made important researches on the spectrum of the corona obtained in full sunlight, determining wave-lengths and intensity of emission lines from  $\lambda$  3328 Å. to  $\lambda$  10,798 Å.

Of the work done at *Arcetri*, mention may be made of the systematic difference found between the line intensities at the equatorial and polar limbs probably in relation to the greater height of the chromosphere at the poles and to the difference in temperature between the poles and the equator, in agreement with some solar theories. At the eclipse of June 19, 1936 a good spectrum of the corona was obtained by the Italian expedition to Sara (U.S.S.R.), which is being studied at *Arcetri* by Righini.

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Upon the request of the President, Prof. Minnaert has drawn up the following general statement concerning the work done in this subject:

It will be found that these reports, juxtaposed in the right way, and completed by some parts of the reports on sunspots, chromosphere, eclipses and spectrophotometry, give a surprisingly complete review of all different aspects of Solar Physics. By a process of automatic adjustment, the work has been nicely distributed among the individual astrophysicists. Perhaps the only important subject which seems very incompletely mentioned is the photometry of faculae, sunspots and disturbed areas of the solar surface, their continuous radiation and especially their line profiles at different distances from the limb.

While thus the enumeration of the detailed subjects of our work seems relatively complete, we have to consider also from a more general point of view whether we are already able to answer the simplest fundamental questions about the sun which are the proper aim of heliophysical investigation. It will be seen how little real knowledge we have, and how difficult it is to make progress.

What is the hydrogen content of the sun?

How strong is the influence of turbulence in the solar atmosphere?

What is a Fraunhofer line? A correct theory should explain the changes at the limb, subordinate line profiles, influence of collisions, etc.

Origin and properties of the far ultra-violet solar radiation,  $10^6$  times stronger than that of a black body.

Equilibrium of chromosphere and corona.

The peculiar law of the solar rotation.

The question of the origin of solar energy should be added, but, evidently, this can only be solved in connection with the study of stars, and is not a real solar problem.

Our ignorance about these important questions is striking; and it seems that present work should, in the first place, be directed towards their solution.

Opportunities for co-operation have rarely been found in our Commission. Members are invited to consider again such possibilities and to propose useful schemes at the next meeting.

GIORGIO ABETTI

*President of the Commission*