REPORT

OF THE

KODAIKANAL OBSERVATORY

FOR THE YEAR

1922

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REPORT OF THE KODAIKANAL OBSERVATORY FOR THE YEAR 1922.

This report is concerned solely with the astronomical, seismological and magnetic work of the Kodaikanal Observatory. Administrative details will be transferred to the Annual Administration Report of the Meteorological Department. The meteorological section hitherto published as appendices will be omitted and in future this will be published by the Meteorological Department in the "Monthly Weather Review."

The report of the Madras Observatory will not be included.

With a view to effect economy in postage and paper the royal octavo size will in future be adopted.

2. *Weather conditions.*—With a total rainfall of 86·52 inches, the highest on record since the Observatory was started, the general conditions were not favourable for astronomical work. The mean definition in the north dome before 10 a.m. was only 2·9 on a scale in which 1 is the worst and 5 the best, while the number of days in which the definition was estimated as 4 or above was only 22.

3. *Photoheliograph.*—Photographs on a scale of 8 inches to the Sun's diameter were taken on 324 days, using the 6-inch visual achromatic object glass and a green colour screen.

4. *Spectroheliographs.*—Monochromatic images of the Sun's disc in K light were obtained on 322 days, prominence plates on 273 days and Hα disc plates on 213 days.

5. *Six-inch Cooke Equatorial and spectroscope.*—Work with this instrument has been continued on the same lines as formerly for visual observations of solar phenomena which cannot be readily photographed.

6. *Grating spectrograph.*—The study of the sodium lines D_1 and D_2 in Sun and arc has been continued. By using a potash salt such as potassium metabisulphite and carbon poles very narrow and sharply defined emission lines are produced in the arc, D_2 usually showing a very fine absorption line displaced towards red about 0·005A with respect to the emission line. Measuring the emission lines only, this series of plates gives much larger Sun – arc displacements than were obtained in 1921, using the absorption lines in D_1 and D_2 given by a sodium salt in the arc.

The mean shift Sun – arc at the centre of the disc is for D_1 + 0·006A and D_2 + 0·010A, and there appears to be no increase of shift at the limb such as occurs with the iron lines. The difference of shift for the two lines is practically the same as in the 1921 plates and indicates a zero pressure in the reversing layer. To obtain the true Sun – arc shift we

therefore add to the observed shifts the shift due to the air pressure at Kodaikanal. According to Humphreys' measures this would be approximately + 0·010A for D_1 and + 0·008A for D_2, which would give a mean shift for D_1 and D_2 of about + 0·017A ; a figure comparable with the Einstein shift of +0·012A. But further investigation is necessary as there is evidence showing that the fine emission lines of sodium obtained with a potash salt are displaced slightly towards violet and therefore give too large a value of the shift, also the pressure shift at $\frac{3}{4}$ atmosphere is somewhat uncertain. Direct comparison of the arc in vacuo with the Sun would give more reliable results.

The D line measures near the equatorial limbs have been used to give a value of the solar rotation. The mean result of 12 plates taken between the 24th and 31st March 1922 give 1·937 km/sec as the sidereal velocity at the equator, a value in close agreement with recent measures by the spectrographic method. Considering the high level in the reversing layer which the D lines are generally believed to represent, this is rather an unexpected result.

The prism spectrograph has been found to be very efficient in the ultra violet as far as λ 3800, where the dispersion is 2 mm. to the angstrom, and the resolution almost equal to the third order of the large grating. The spectra are superior to the grating spectra in contrast and the exposure time is shorter. During December an excellent series of Sun and Fe arc spectra have been obtained including the lines H and K and the cyanogen band at λ 3883 for comparison with grating plates taken in former years. The measures have not been completed, but a comparison of the mean results so far obtained with those of 1913, 1914 and 1921 appears to show that a few of the stronger iron lines, such as λλ 3902, 3920, 3922, 3927 and 3930, undergo appreciable changes of wave-length at the centre of the disc, amounting at the most to 0·005A. At the limb where these lines are more sharply defined and easier to measure the differences are still more marked, the changes observed in the case of 3902 and 3927 amounting to 0·008A.

7. *Venus spectra.*—Photographs of Venus spectra were taken with the prism spectrograph in April and in June. Plates taken with this equipment in December 1921 when the angle Venus-Sun-Earth exceeded 140° gave values of the shifts Sun − arc practically identical with those in direct sunlight ; and the same results are now obtained from the 1922 series with the planet on the opposite side of the Sun. As these prism spectra are of perfect definition and superior to the grating plates of 1918–1920 which gave smaller wave-lengths in the light reflected by the planet compared with direct sunlight, it is concluded that the latter are affected by a systematic error the origin of which is difficult to determine. It has been proved in various ways that unsymmetrical illumination of the slit due to atmospheric dispersion will not account for it but it seems possible that a slight admixture of skylight might affect the measures even when there is no visible evidence of it in the spectra. However this may be, it now appears certain that the lines are shifted towards red in light from all parts of the Sun, there being no difference between the visible and invisible hemispheres.

The general shift of the iron lines increasing from the centre towards the limb cannot therefore be explained by motion alone, and our researches on the whole seem to support the Einstein gravitational

effect combined with a radial outflow of the iron vapour, varying according to level, and possibly varying with the sunspot period.

The prism spectrograph has also been employed in photographing the spectrum of Sirius with very high dispersion. The remarkable character of the lines in the Sirius spectrum has been described in the Monthly Notices of the Royal Astronomical Society 82, 392. In October at Broome, West Australia, spectrum photographs were obtained of Canopus and of Achernar, but neither of these stars resembles Sirius in the character of its lines.

8. Dr. Royds has investigated the effect on wave-length of the addition of various substances into the electric arc for a few selected lines of copper and calcium. With copper as the positive pole and carbon as the negative it is found that, under the most favourable conditions, adding the following substances to the copper head on the positive pole caused displacements of the line λ 4531 of the amounts quoted:—metallic sodium + 0·048A, calcium chloride + 0·035A, soda glass + 0·032A, sodium carbonate + 0·025A, iron + 0·017A, silver + 0·015A, aluminium + 0·014A, nickel + 0·009A, potassium carbonate + 0·006A. The line λ 4480 undergoes about equal displacement, and λ 4509, which is not so unsymmetrically widened towards the red, has a displacement less than half. Adding the following substances to a flame arc carbon as positive pole with carbon as negative produced the given displacements of the calcium triplet λλ 4578—81—86 :—copper + 0·002A, soda glass − 0·002A, iron − 0·005A, silver coin − 0·013A, nickel coin − 0·020A. These displacements of unsymmetrically widened lines can probably be explained by the view that widening and displacement are caused by the electrical field due to neighbouring ions. The introduction of different substances into the arc causes differences in the electrical field near an atom by altering the number of ions in the arc, in possibly two ways, (1) owing to greater or less ease of ionisation of these substances, and (2) owing to alteration of arc conditions due to differences in volatility, etc.

It has been previously found that in the first subordinates series of barium the second member is unsymmetrically widened in the opposite direction to that of succeeding members. Other examples of series anomalous in this respect have been found, and the anomaly appears to follow the behaviour in an electric field.

Although the unsymmetrical character of spectrum lines can be shown to be almost indubitably an effect of the electrical field due to the ions surrounding the emitting atom, the conditions in the electric arc are not at present sufficiently known to enable this fact to be applied to a definite determination of conditions in the Sun, where unsymmetrical lines undergo abnormal displacements.

9. *Eclipse expedition.*—Preparations for the solar eclipse of September 21 involved a large amount of construction work during the first seven months of the year. The main purpose of the expedition was to photograph the star field surrounding the Sun on a very large scale, using a 12-inch photo visual lens of 21 feet focus, and to determine the deflection of light near the Sun by comparison with photographs taken later in India with the star field at the same altitude in the morning sky. In addition, two prism spectrographs were constructed for photographing the displacements of the green corona line at the east and west limbs simultaneously by means of a simple optical device.

The work was beset by serious difficulties from the beginning. The large lens appeared to be defective, but this was finally traced to the action of the mirror used, and of three plane mirrors that were available, made by three British firms of repute, not one was found to be free from serious defects. A mirror was therefore ordered from Hilger, but was not received in time : and this one alone appears to be good. The 16-inch coelostat lent by the Joint Eclipse Committee was found to give a varying rate of drive, notwithstanding the new driving clock that had been provided for it : this involved the construction and careful grinding of a new driving screw, and the refiguring of the sector, entailing strenuous work up to the day of despatch of the instruments to Australia.

All this work was of no avail, however, and the large Einstein camera failed at the critical time, mainly on account of slight outstanding irregularities in the driving of the coelostat combined with astigmatism of the mirror. The spectrographs also failed to record the corona line, which appears to have been abnormally weak at the time of the eclipse.

The weather conditions at Wallal, W. Australia were about as perfect as can ever be realised at an eclipse, and so a unique opportunity for solving the deflection problem was lost, owing to bad workmanship in the coelostat.

Funds for the expedition were provided by a special grant from the Government of India of a sum equivalent to about £300, and the members of the expedition were the guests of the Australian Government while at Wallal.

Summary of sunspot and prominences observations.

10. *Sunspots.*—The following table shows the monthly numbers of new groups observed at Kodaikanal and their distribution between the northern and southern hemispheres. The mean daily numbers of spots visible are also given :—

—	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
New groups ...	10	8	14	5	1	5	5	4	2	5	3	6	68
North	6	4	9	4	1	4	2	2	...	2	2	3	39
South	4	4	5	1	...	1	3	2	2	3	1	3	29
Daily numbers ...	1·3	1·6	2·9	1·2	0·6	0·6	0·7	0·5	0·4	0·8	0·7	1·4	1·1

Compared with the year 1921, there was a decrease in the case of new groups, amounting to 28 per cent in the northern hemisphere and 48 per cent in the southern.

The approximate mean latitude of the spots was 8°·5 and 8°·2 respectively in the two hemispheres.

With the exception of a large and fairly active group which crossed the central meridian on December 29, the majority of the spots were small scattered groups of short duration. A small but longlived group

which was first visible in November 1921 returned four times and finally disappeared in March 1922.

The number of bright reversals of the Hα line recorded in the neighbourhood of spots was 150, whilst the number of displacements observed near spots was 55, of which 41 were towards the red. D_3 was observed as a dark line on 43 occasions.

11. *Prominences.*—The mean daily areas in square minutes of arc derived from the photographic records are shown below :—

	North.	South.	Total.
1922—January to June	1·90	1·27	3·17
July to December	1·58	1·70	3·28

The mean daily numbers decreased from 11·1 in the first half of the year to 10·4 in the second.

The distribution in latitude was nearly the same during the two periods of six months, but there has been a steady increase of latitude in the northern zone of greatest activity amounting to 5° per annum, the zone advancing from + 40° during the earlier months of 1921 to + 50° during the later months of 1922.

A similar zone of activity in the south has during the same period moved at the same rate in the opposite direction from − 53° to − 43°. Such fluctuations are not without precedent during this period of the solar cycle, and the regular increase of latitude in both hemispheres culminating at the poles is not likely to begin until after the year of minimum activity of sunspots.

There was a further decline in the number of metallic prominences observed, only 41 being recorded of which 34 were observed during the first six months of the year. 33 were recorded in the northern hemisphere and eight in the southern.

315 displacements of the hydrogen lines were observed of which 179 were towards the red.

Prominences projected on the disc as absorption markings showed a large decrease during the second half of the year.

There was an excess of prominence area on the west limb during the first half-year and on the east limb during the second, whilst Hα absorption markings showed a large eastern excess throughout the year.

12. *Magnetic observations.*—Continuous magnetograph records and absolute observations were obtained as in former years, and the records were sent to the Magnetic Survey Office, Dehra Dun.

132 "Moderate" magnetic storms were registered during the year. No "Great" storms occurred.

13. *Seismology.*—The Milne horizontal pendulum recorded 93 earthquakes during the year. For details of the records reference may be made to the "Monthly Weather Review" of the Indian Meteorological Department.

14. *Library.*—86 volumes were bound during the year.

15. *Publications.*—The annual report for the year 1921 and bulletins Nos. 69 and 70 dealing with prominence observations made in the second half of 1921 and the first half of 1922 were published and distributed during the year.

In addition the Director has contributed a paper on "Widened Lines in the Spectrum of Sirius" to the Monthly Notices of the Royal Astronomical Society 82, 392. See also "Observatory" 45, 296.

Mr. Chidambara Ayyar has contributed a paper on the star Alcor about 2300 years ago—Journal of the British Astronomical Association, 32, 315.

KODAIKANAL,
1st February 1923.

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