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# UNUSUAL SOLAR ACTIVITY

By MD. SALARUDDIN, B.A., M.Sc.

AND

B. G. NARAYAN, B.Sc.

*(Received for publication, Nov. 29, 1939)*

Plates XX & XXI

**ABSTRACT.** The paper describes briefly the outstanding features of a recent persistent solar activity observed in Kodaikanal.

Attempts have been made to correlate the bright chromospheric eruptions with the terrestrial effects. It is suggested that until many more data are obtained, judgment must be withheld regarding the nature of the relation between the eruptions and terrestrial magnetic disturbances.

Persistent solar activity was observed for about three weeks commencing from the 26th August, 1939, and one of its remarkable features was that it was practically confined to a zone in the neighbourhood of latitude 15° in the southern hemisphere. The first signs of this spell of activity were noticed simultaneously with the appearance of the spot group Kodaikanal No. 7152 at the east limb at latitude 15°S. This long-lived spot group had already gone round the sun twice bofore without showing much activity. On the 26th August, however, a flocculus in the neighbourhood of this spot brightened up and showed considerable Doppler displacements. The maximum Doppler shift observed in the flocculus was 2·4 Å to red at $8^h45^m$ I.S.T., indicating a velocity of recession (with respect to the observer) of the order of 110 Km./sec. A prominence connected with the spot group was also active and showed a displacement of 1 Å to violet. On the same day, eruptions were observed in the neighbourhood of spot groups Nos. 7148 and 7150, the latter of which was near latitude 15° S, but the former was in the northern hemisphere.

The spot group No. 7152 continued to be very active throughout its passage across the solar disc and gave rise to eruptions almost every day. The most extensive of these occurred on August the 30th, its area being 500 millionths of the sun's visible hemisphere. The region of the spot group was showing signs of activity even from the morning. A dark marking to the north of the spot group showed displacements of 2 Å to violet and 2 Å to red at different points at $8^h35^m$. A point to the south of the group brightened up at $9^h0^m$ but subsided to its normal brightness at $9^h55^m$. But the eruption proper began at $11^h30^m$ and very soon

extended all round in long streaks. Its intensity as measured with a graduated step-wedge was 3 times that of the undisturbed disc. The eruptive area showed good Doppler displacements, the maximum displacement being 2.4 Å to red at $11^h55^m$. In the accompanying plate spectro-heliogram 1 (*a*) shows the region of the spot group at $8^h26^m$ before the eruption began and the spectro-heliograms 1 (*b*) to 1 (*e*) show the region at the time of the eruption between $11^h49^m$ and $11^h52^m$.

Another eruption was observed on September 1. Though smaller in area, this was very much brighter than that of August 30. The $H_\alpha$ and K spectro-heliograms taken before $8^h0^m$ showed no appreciable activity in the region of the spot group and nothing extraordinary was noted bythe spectro-helioscope observer till $8^h25^m$ when suddenly the flocculus adjacent to the leading spot of the group brightened up and became eruptive. It soon extended in a narrow column towards the east and joined up with one of the following spots of the group. At the same time there was another bright column seen starting up from one of the following spots and extending in a southwestwardly direction. The eruption attained its maximum brightness at about $8^h45^m$ and then the intensity fell off gradually, the whole activity subsiding by $9^h30^m$. No Doppler displacement was noticeable in the eruptive area but two small dark markings lying to the north and south of the spot group showed some displacements.

From observations with the spectro-helioscope it was found that this large spot group was very active on the morning of the 2nd September. No less than three eruptions were observed between $8^h10^m$ and $11^h20^m$ in the large flocculus surrounding the spot, the times of maximum intensity for these three outbursts being $8^h28^m$, $10^h12^m$ and $10^h50^m$. In this case the eruption obviously took the form of a series of brightenings of different parts of the flocculus.

A very bright eruption occurred in the same region on September 6. The eruption began at $8^h17^m$, reached its maximum intensity at $8^h27^m$ and faded away at about $0^h0^m$. Doppler displacements of 1.0 Å to violet at $8^h17^m$ and 2.0 Å to red at $8^h30^m$ were noted in the region by the spectro-helioscope observer.

The spot group gave rise to active and metallic prominences at the west limb on the 7th and 8th September. The spectroscope showed most of the lines belonging to sodium, iron and magnesium usually observed in the prominences. Doppler displacements of about 2 Å to both red and violet were observed. Photographs of these prominences in calcium light taken on the 7th and 8th September are reproduced here in figures 2 (a) and 2 (b) respectively (see plate XX).

Two other very active spot groups that crossed the sun's disc during the period are the Kodaikanal Nos. 7157 and 7159. These spots were also situated in the neighbourhood of latitude 15° in the southern hemisphere. The spot No. 7157 gave rise to an eruptive prominence on September 1. The prominence was not visible in the earlier photographs but suddenly appeared at about $9^h0^m$ and showed extraordinary activity, attaining a height of more than 4′ (perhaps 5

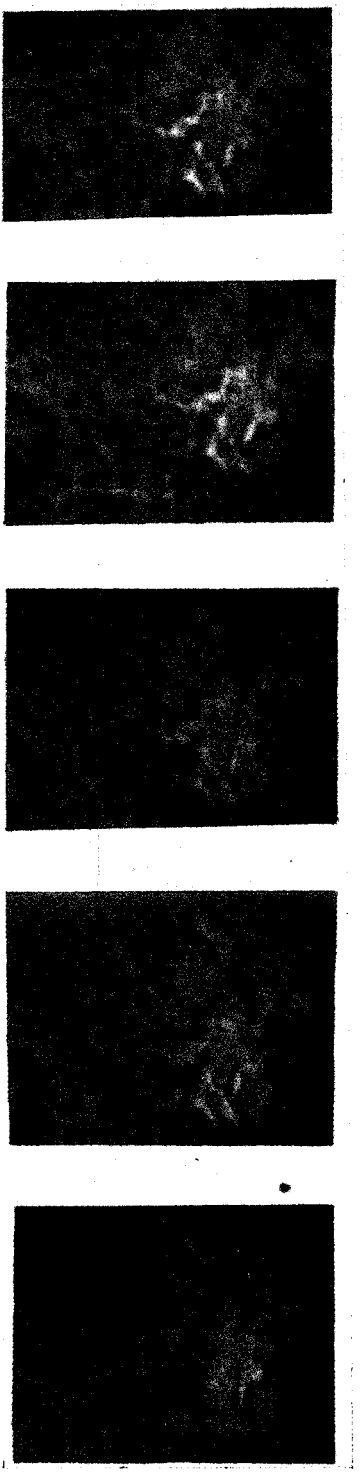


Fig. 1.

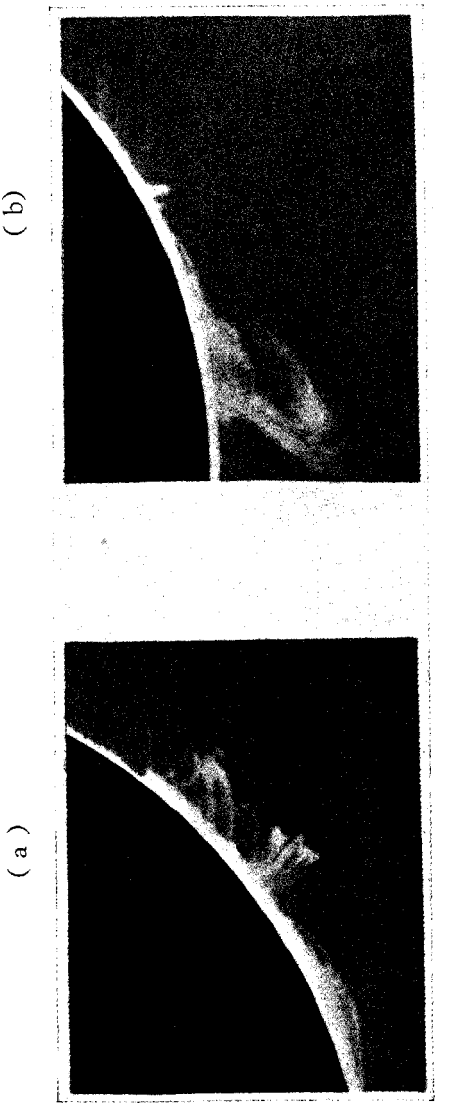


Fig. 2.

which is equal to 217,500 Kms.) during a very short time. The prominence was metallic and all the lines usually observed were seen in the spectroscope. The maximum displacements observed in the prominence were 6 Å to red (velocity of recession 275 Km./sec. and 9 Å to violet (velocity of approach 410 Km./sec.) at $9^h25^m$. The prominence completely disappeared at $9^h55^m$.

A number of eruptions were also associated with the spot group No. 7159 and as many as three of these occurred on the morning of the 6th September alone. The first one began at $8^h32^m$, attained its maximum brightness at $8^h35^m$ and subsided by $9^h0^m$. Another eruption was observed to begin at $9^h28^m$ and it lasted till $9^h40^m$ reaching its maximum intensity at $9^h36^m$. The third eruption in the same region, which was the brightest of all, began at $9^h45^m$ and though it attained its maximum intensity at $9^h\ 50^m$ did not subside till two hours later. A series of 21 spectro-heliograms of this eruption was obtained in $H\alpha$ light and the more important ones are reproduced in figures 3 (a) to 3 (e) (see plate XXI).

Apart from these eruptions, the other important phenomena noted during the period are the breaking up of $H\alpha$ dark markings. Instances of breaking up of markings were observed on the 26th August and on the 2nd and 12th September. The last of these was remarkable in as much as a big marking, which was seen for a number of days, completely disappeared in a very short interval. This marking is shown by means of an arrow head in the spectro-heliogram figure 4 (a) taken at $8^h17^m$ on September 12. It is seen that the northern end of the marking is connected with the spot No. 7157, the other end of the marking establishing a contact with the spot group No. 7159. Nothing special was noted in the marking till about $9^h32^m$, when suddenly the end of the marking close to the spot group No. 7159 began to show a displacement of about 1.2 Å to violet indicating an outward rush of matter from one of the spots of the group. At the same time a displacement of 1·0 Å to red in the portion of the marking about the middle, *i.e.*, nearest the west limb was observed indicating that the matter coming out of the spot was moving towards the limb. The displacement towards red gradually increased and was about 2·5 Å at $9^h45^m$. A streak was clearly seen starting from this point of the marking and advancing towards the limb giving rise to a prominence which is reproduced here in figure 4 (b). The maximum height attained by the prominence was about 3′. Perhaps its height was actually much greater, but it could not be measured as the top was cut off in all the three photographs taken that morning. After a short time the prominence as well as the dark marking completely disappeared. As can be seen from the spectro-heliogram figure 4(c) taken at $10^h26^m$, there is no trace of the dark marking, but on the other hand there is a bright marking exactly in the same place where the dark marking was before. The bright marking is clearly the base of the prominence that disappeared and is a good example in support of the conclusions arrived at in a previous bulletin[1] that the lowest parts of a prominence being much brighter than the surrounding disc show themselves by emission, and

that only the higher portions of a prominence show themselves by absorption on the disc.

It is a well-known fact that photographs of the sun's disc taken in monochromatic light show decided contrast between the intensity of a sunspot and that of the surrounding region on the disc. If it is assumed that these brilliant chromospheric outbursts are associated with exceptionally high temperature, they should show themselves conspicuously in the monochromatic images taken at the time of their occurrence. Photographs taken at this observatory on several occasions in regions free from absorption lines fail to show any images corresponding to the eruptions shown in the photographs taken in $H_\alpha$ line or the line of calcium. It seems therefore reasonable to conclude that the active agent producing both the eruption and the observed terrestrial effects originates in layers lower than the chromosphere, below the eruptive patch.

Correlations between solar eruptions and disturbances in terrestrial magnetic elements have been cited by A. G. McNish[2] who found that the magnetic disturbances produced by the chromospheric eruptions are unique and that in almost every case they are augmentations of the normal diurnal variations in geomagnetism. Although the persistent activity with frequent appearance of unusually bright and extensive eruptions mentioned in the present study extended over several days, Alibag magnetic records did not reveal any magnetic disturbance of sufficient importance. It would appear that the connection between the eruptions and the magnetic effects is not a simple one and there is need for further careful studies of the diurnal variations accompanying solar outbursts.

It has not been possible to study the connection between these solar flares and the associated radio effects, as continuous series of daily records regarding the behaviour of the ionosphere are not available in India.

In conclusion the authors wish to express their thanks to the Director and Assistant Director for their helpful criticisms and suggestions.

THE SOLAR PHYSICS OBSERVATORY,
KODAIKANAL.

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[2] A. G. McNish *Phys. Rev.*, **52**, 155-160 (1937). *Cinquieme Rapport de la Commission Pour L'ietude*, pp. 105-110, 1938.

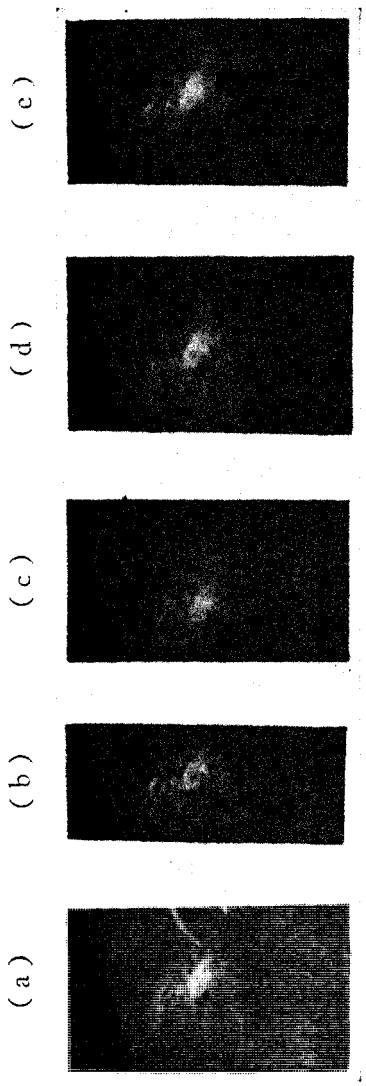


Fig. 3.

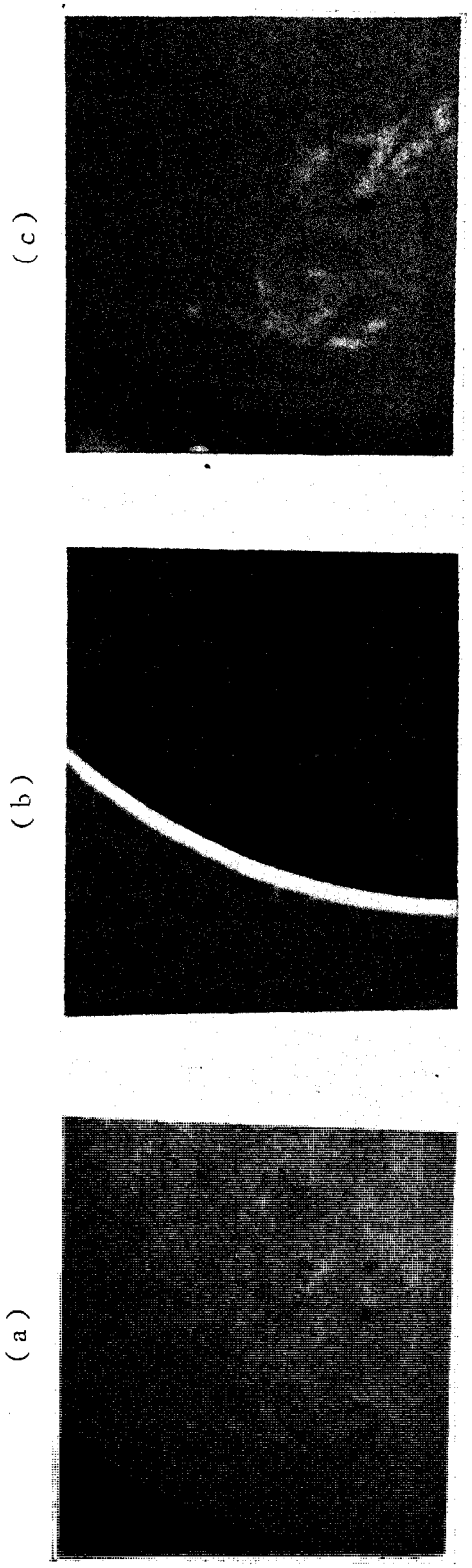


Fig. 4.