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Sun-spots and Magnetic Storms during the last week of March, 1940

The period between March 24th and April 2nd, 1940, was marked with severe magnetic disturbances attended with widespread interference with both radio and cable communications. The Alibag Observatory magnetograms show that a severe magnetic storm commenced at $19^h\ 20^m$ I.S.T. on March 24, 1940 with a sudden increase of 62 gammas in H and 1'.3 westerly D. There was a fall of 10 gammas in Z. This storm lasted till about $16^h\ 30^m$ on March 25. Eight hours later, a moderate disturbance began and continued till $12^h\ 30^m$ on the 26th. On the 29th March at 21 32^m another storm of great intensity began with sudden commencements in all elements and ended at 8^h on March 31st. After a short interval of slight activity, a fresh disturbance of great intensity commenced at $15^h\ 12^m$ on the same date and continued till 4^h on April 2nd.

Simultaneously with these magnetic storms, reports have been received of great dislocation in the radio and cable communications all over the world. It is reported that the United States suffered most severely and communications to Europe and South America were crippled for hours together. Britain's overseas radio and cable communications also suffered and in India too radio reception, especially on short waves, was very much affected.

The magnetic storms and the radio disturbances have long been attributed to the presence of large and active sun-spots near the central meridian of the sun. During the last few years, a number of papers have also been published correlating the bright chromospheric eruptions in the sun with terrestrial magnetic disturbances and radio fade-outs. A study of these solar flares and the nature of the relation that exists between these and the associated terrestrial effects leads to a better understanding of the physical state of the upper atmosphere. In the present paper, an account is given of the sun-spot group associated with the magnetic storms and the radio disturbances, during the period under consideration.

This is a large bipolar group of spots at latitude 12°N which crossed the central meridian of the sun on the 26th March, 1940. It is a long lived spot group which had already passed the sun's visible disc thrice before making its present appearance. In the first rotation, this appeared as two distinct spot groups *viz.*, Kodaikanal numbers 7252 and 7253 which were about 10° apart. Each group consisted of a number of smaller spots and they were first seen near the east limb on 30-12-39 and 1-1-40 respectively. No special activity was noticed in these groups till 3-1-40 when the spectrohelioscope observations showed a brightening up of the flocculus in the surrounding region. The flocculus was very bright the next day also and showed a Doppler displacement of 1.0 A to the red indicating a velocity of approach of 45 km/sec. towards the sun. When seen on the 5th January, the spot groups had already developed into a large bipolar group which was very active. An eruption was photographed in the region on the 6th January between $8^h\ 20^m$ and $9^h\ 15^m$ I.S.T. and a dark marking in the neighbourhood showed a displacement of 2.4 A to the red. The spot group continued to be active till the 12th January when it passed the west limb. No information is available about the radio fade-outs during the period, but the Alibag Observatory reported a great magnetic disturbance on 3-1-40, namely when the group was about 26° east of the central meridian.

The spot group exhibited no special activity in the next two rotations across the sun's disc. In its fourth rotation, it was first seen near the east limb on 21-3-40. It was still a bipolar group and was active. Hα dark markings in the neighbourhood showed displacements of 1 to 2 A to the red. Eruptions were photographed in the region on the 23rd, 24th and 25th. On the 24th March *i.e.*, on the day of the commencement of the severe magnetic storm and radio disturbances, the spot group was about 20° east of the central meridian. It was a fairly large group covering an area of about 1450 millionths of the sun's visible hemisphere. The leading spot which was the most active of the two was large and irregular in shape, with the umbra broken up into a number of smaller portions. The following spot was a smaller one with a regular outline.

Great activity was observed in the region of the spot group from the 29th March, when an eruption was photographed between $9^h\ 53^m$ and $10^h\ 1^m$. On the 30th March two eruptions were recorded between $8^h\ 4^m$ and $11^h\ 35^m$. The first of these was observed at $8^h\ 4^m$ at two points adjoining the leading spot. Its intensity was 3 times that of the undisturbed disc as viewed in the spectrohelioscope by inserting a step-wedge between the eye-piece and the rotating prisms. The eruptive portion showed a Doppler displacement of 0.6 A to the red and 1.0 A to the violet at $8^h\ 10^m$.

At $8^h\ 23^m$ a small dark marking near the spot was showing a displacement of 0.6 A to the violet at its end away from the spot and a displacement of 1.6 A to the red at the end nearer the spot, indicating that the whole marking was being pulled into the spot. The eruption subsided at about $9^h\ 10^m$. Another eruption commenced just before 11^h. This was a much larger eruption which started from the leading spot and extended in two streaks towards the following spot. The eruptive portion nearer the following spot was showing a displacement of 2.0 A to the red indicating that the eruptive matter had been flowing into the following spot at a velocity of about 90 km per second. From these observations, it is not possible to conclude that either the spot group or the eruptions that it gave rise to are entirely responsible for the magnetic storms and the radio disturbances experienced during the period under consideration. It is well known that a magnetic storm often happens when a large and active sun-spot passes the central meridian of the sun. But in this particular case, the two great magnetic storms commenced about 2 days before and 3 days after the spot group had crossed the central meridian. Further, no magnetic storms were recorded during the previous three passages of the spot group excepting the feeble one of 3-1-40

It has been found that terrestrial magnetic disturbances and the radio fade-outs that have their origin in these eruptions last only for short intervals of about 10 minutes to 1 hour and they manifest themselves only on the illuminated side of the earth. The present magnetic storms and associated radio disturbances lasted for days together and manifested themselves with equal intensity both on the illuminated and dark sides of the globe. The cause of these therefore is some other than the sudden ionisation caused by the chromospheric eruptions. Investigation of a large number of eruptions and the associated terrestrial effects indicates that a number of large and active spots are not accompanied by magnetic storms and a number of magnetic storms occur without any large spot on the sun. While no definite conclusions as to the genesis of magnetic storms and radio effects can be derived, one is forced to the belief that the active agent linking the effects on the sun with the terrestrial disturbances originates in an affected region lying beneath the spot.

M. Salaruddin
C. K. Ananthasubrahmanyam.

Solar Physics Observatory
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