The Geomagnetic solar flare effect of 6 July 1968 and its implications

by

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Introduction

The sudden short lived perturbation in the geomagnetic variation in the sunlit hemisphere concurrent with the occurrence of a solar flare is known as SFE (Crochet). The characteristics of SFE have been studied over the past three decades and are now well known (refer to the review paper of Nagata, 1966 and Richmond and Venkateswaran, 1971). Recently, Kivistava (1974) observed for the SFE of 3 May 1973, the amplitude in the H-component of the SFE to be relatively low at equatorial electrojet stations compared to that at stations outside the electrojet; which feature he attributed to the presence of a 'counter-electrojet' current system flowing from east to west. This understanding stems from the fact that the amplitude of SFE (in the H-component) is usually larger at equatorial electrojet stations compared to that at stations outside the electrojet (Pisharoty and Joseph, 1963).

In this brief communication, the characteristics of the geomagnetic solar flare effect (SFE) of 6 July 1968 as observed at five Indian magnetic observatories, are presented and the implications of its unique features are discussed. The names and coordinates of the stations are listed in Table 1. The locations of the stations and that of the electrojet are depicted in Figure 1. It may be noticed that while Alibag and Hyderabad lie outside the influence of the equatorial electrojet, Annamalainagar, Kodaikanal and Trivandrum are situated well within the electrojet. The geomagnetic solar flare effect of 6 July 1968 which occurred with a solar flare of importance 2B is a confirmed event as Sudden Ionospheric Disturbances

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Fig. 1
A map showing the locations of the five magnetic observatories and the equatorial electrojet.

Fig. 2
The geomagnetic solar flare effect (SFE) of 6 July 1968 at the five Indian stations showing the decrease in the $H$-component at electrojet stations and the increase in the $H$-component at stations outside the electrojet.

Observation

Figure 2 shows the geomagnetic solar flare effect of 6 July 1968 as evidenced in the $H$-traces of the normal run magnetograms of the five stations mentioned. The characteristics of this SFE as observed at the various stations are presented in Table 1. The amplitude of SFE at each station is obtained from the difference in the value of the $H$-component at the maximum (or minimum) of the SFE and the average value at the beginning and end of the SFE, following accepted practice. The unique feature of this SFE, as can be clearly seen from figure 2 and Table 1, is that although the amplitude in the $H$-component of the SFE increases with decrease in latitude, the sign of the perturbation is consistently negative at all the three electrojet stations, while it is positive at the two stations outside the influence of the electrojet.

Discussion

A plausible cause of the above described characteristic of the SFE of 6 July 1968 could be the existence of a 'counter-electrojet' current system in the equatorial region at the time of occurrence of the solar flare effect. The presence of 'counter-electrojet' in the equatorial region which manifests itself as a negative effect in the diurnal variation of the horizontal component around 0700 hr, noon and 1500 hr local time has been brought to light by Gouin and Mayaud (1967). Later studies showed the phenomenon of 'counter-electrojet' to occur most frequently around sunspot minimum period and when the magnetic activity is very low; and is closely associated with the disappearance of equatorial Es (Esq) and reversal of drift direction of electrons from westward to eastward (Hutton and Oyinloye, 1970; Sastri and Jayakar, 1972; Rastogi et al, 1971; Krishnamurthy and Sen Gupta, 1972). The cause mechanism responsible for 'counter-electrojet' current system is however yet to be established. Van Sabben (1968) interpreted the counter-electrojet as an equatorial anomaly associated with the SFE current system following the
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Table I

<table>
<thead>
<tr>
<th>Observatory</th>
<th>Geographic coordinates</th>
<th>Dip(I)</th>
<th>Characteristics of SFE</th>
<th>SFE Amplitude in Gammas (H-component)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lat.</td>
<td>Long.</td>
<td></td>
<td>Start</td>
</tr>
<tr>
<td>Alibag</td>
<td>18 38'N</td>
<td>72 52'E</td>
<td>24.4</td>
<td>0940</td>
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<tr>
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<td>78 33'E</td>
<td>20.5</td>
<td>0942</td>
</tr>
<tr>
<td>Annamalainagar</td>
<td>11 22'N</td>
<td>79 41'E</td>
<td>5.4</td>
<td>0942</td>
</tr>
<tr>
<td>Kodaikanal</td>
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<td>77 28'E</td>
<td>3.0</td>
<td>0939</td>
</tr>
<tr>
<td>Trivandrum</td>
<td>11 35'N</td>
<td>76 57'E</td>
<td>- 1.0</td>
<td>0941</td>
</tr>
<tr>
<td>Associated SID's : SWF: 0948 - 1010E - 1020U U.T.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SCNA: 0945 - 0949</td>
<td>1015</td>
<td>U.T.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SEA: 0940 - 0945</td>
<td>- 1042</td>
<td>U.T.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPA: 0940 - 0943</td>
<td>- 1200</td>
<td>U.T.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SES: 0940 - 0949</td>
<td>- 1110</td>
<td>U.T.</td>
<td></td>
</tr>
</tbody>
</table>

1. July 1968 is one of the quiet days of the month, the value of $A_p$ for this day is 6.0 and the magnetic character figure $C_s$ is 0.3. In figure 3 is shown the magnetogram of Kodaikanal on 6 July 1968. It can be seen that there is an indication of a 'counter-electrojet' on this day just prior to and after the occurrence of SFE, as during this period the value of the horizontal component of the magnetic field is below the average night time level (shown by the dotted line in figure 3). In Plate I are shown the ionograms of Kodaikanal around the time of occurrence of the SFE on 6 July 1968. It can be seen that at 1330 hrs I.S.T. (0800 U.T.), well before the occurrence of SFE, equatorial sporadic-E (Es) is present. The $E_s$ configuration underwent drastic changes in the next 30 minutes and by 1400 hrs I.S.T. (0830 U.T.) it is of total blanketing type (Eab). This is expected as it is known that the occurrence of blanketing $E_s$ at Kodaikanal is usually accompanied by a decrease in the $H$-component and disappearance of equatorial sporadic-$E$ ($E$ (Bhargava and Subrahmanyan, 1964). Equatorial sporadic-$E$ ($E_s$) is again seen at 1500 hrs I.S.T. (0930 U.T.) when the $H$-component value just crossed the average night time level. The solar flare effect on vertical sounding is then seen with total fade-out at 1530 hrs I.S.T. (1000 U.T.) and with the progress of time the recovery of the ionogram trace took place. It is interesting to note that at 1630 hrs I.S.T. (1100 U.T.) when the ionogram trace completely

Fig. 3

Normal run magnetogram of Kodaikanal on 6 July 1968 showing the depression in H-component below the average night time level (counter-electrojet) just prior to and after the occurrence of SFE.
Plate I

Scholgrams of Kodaikanal on 6 July 1968 around the time of occurrence of SFE. Note the conspicuous absence of Es at 1630 hr I.S.T. when the $\phi$-component is below the average night time level (counter-electrojet). Height marks are at intervals of 100 km.

The time indicated is in I.S.T. (U.T. + 0530 hrs).
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The geomagnetic solar flare effect recovered, equatorial sporadic $- E$ (Esq) is conspicuously absent and only normal $E$-region trace is noticed (the value of the $H$-component is below the night time level indicating the presence of "counter-electrojet"). Equatorial sporadic $- E$ (Esq) reappeared only at 1715 hrs I.S.T. (1145 U.T.) when the value of the $H$-component rose well above the night time level. The above observations indicate the existence of a reversed electric current system in the electrojet region just prior to and after the occurrence of the SFE, enabling to interpret the unique features of the SFE, mentioned earlier, as due to "counter-electrojet".

It is fortuitous that the SFE of 6 July 1968 occurred just at the time of the afternoon depression in the $H$-component (manifestation of counter-electrojet) posing some ambiguity as to which is the cause and which is of the effect of the two: counter-electrojet and the characteristics of the SFE current system. However, already mentioned, the work of Hutton and Olunloye (1970) shows that "counter-electrojet" could not be due to the SFE current system as interpreted by Van Sabben (1968). Hence we reach the view that the characteristic features of the SFE of 6 July 1968 are due to the presence of a "counter-electrojet" current system in the equatorial region at the time of occurrence of this SFE.

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References


