Lf Effects at Low Latitudes for the Solar Proton Event of 4 August 1972

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Evidence for effect of solar particle precipitation at low latitudes is presented for the proton event of 4 August 1972. The effect is observed as a significant decrease in single strength of the Lf transmissions from Radio Tashkent (164 kHz) as received in Delhi.

1. Introduction

Extensive studies have been made to delineate the response of polar lower ionosphere to the precipitation of charged particles of solar origin that follow major solar flares with ground based equipment like hf riometers and vlf phase and amplitude measurements. Efforts to make in situ studies of the nature and distribution of the charged particles using satellites and of the ionization by rockets, are of recent origin. These recent techniques, although more resourceful, are essentially limited and in particular, information on changes in ionization, confined to a few rocket launching sites and for any particular event much of the global information comes from ground-based measurements.

One of the handicaps of the hitherto investigations on solar precipitation in earth’s atmosphere is the lack of information of the latitude extent of the effect. It is commonly understood that the solar particles have negligible effect at low latitudes in view of the large cut-off rigidities at such latitudes. However, Mitra et al. reported the observation of solar proton effects at low latitudes for the event of 2 November 1969 using the Lf (164 kHz) field strength data recorded at Delhi. Earlier, Ganguly and Rao reported evidence for the possibility of penetration of high energy solar particles to ionospheric heights at equator using Al absorption data, although their inferences were doubted by Lanzerotti and Graedel. We have examined our 164 kHz field strength data for effects of particle precipitation for the proton events of the retrospective world interval of 26 July to 14 August 1972 and the results are presented below.

2. Experimental Results

We have used the published hourly proton flux data obtained by the solar proton monitoring equipment (SPME) aboard the Explorer-41 satellite (azimuthal inclination 82.8° and apogee 28 earth radii). On 4 August 1972, following a solar flare at 0621 hrs UT, enhancements in proton flux were recorded on all the three channels of proton counters aboard the satellite (>10 Mev, >30 Mev, >60 Mev). The flux (>30 Mev) is 351 protons cm⁻² sec⁻¹ ster⁻¹ at 0900 hrs UT and it rose to very high values during the period 1230 to 2400 hrs UT. Proton flux enhancements have also been noticed on 7 August 1972 starting from 1800 hrs UT although the enhancements are relatively smaller compared to those of 4 August 1972.

We, at the Radio Science Division, National Physical Laboratory, Delhi, have round-the-clock recording of the field strength of Lf transmissions from Radio Tashkent (164 kHz) as part of our extensive and regular programme of radio patrol of solar flares and we have used this data to infer the particle effects, as already mentioned.

In Fig. 1, the continuous curve represents the 164 kHz field strength variation on 4 August 1972. Superimposed on this, is the average field strength variation (curve in dashes) computed from observations for 16 days preceding the event. Also shown in the diagram is the standard deviation (in vertical lines) of the average field strength. This is done to clearly bring out the effect of particle event. At the bottom of Fig. 1 is shown the proton flux (>30 Mev) and at the top the hourly X-ray flux in the two bands (1-8Å and 8-20Å). In response to the flare at 0621 hrs UT, a SCNA event occurred at 0623 hrs UT (Ref. 4). Following this after a delay of about 2½ hr, the proton flux rose to 351 protons cm⁻² sec⁻¹ ster⁻¹ at 0900 hrs UT and it is abnormally high till 2400 hrs UT. The effect of this enhancement in proton flux on the lower ionosphere at low latitudes can be seen as decrease in signal strength starting from 1000 hrs UT with a deep minimum around 1300 hrs UT (Fig. 1). The signal strength recovered back to the expected level around 1400 hrs UT although the proton flux remained quite high. The observed
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Fig. 1—Variations of 164 kHz field strength transmissions from Tashkent as received at Delhi during August 1972. (Numbers given at the top of the figure represent the hourly values of X-ray flux in the two bands 1-8 Å and 8-20 Å)

decrease in signal strength is understandable, as the high energy particles if they penetrate to ionospheric heights, will produce excess ionization at considerably lower levels in the lower ionosphere with the consequent absorption of the signal.

The effect of the proton event of 7 August 1972 on If field strength could not be studied as the record was not obtained due to inking trouble with the pen recorder.

3. Conclusion

The current investigation lends further support to the inference reached earlier by Mitra et al.1 for the proton event of 2 November 1969, that the effect of charged particles of solar origin at low latitudes is a possibility at least for some events. This observation does not fit into the theories on particle precipitation in the earth's atmosphere as the cut-off rigidities at these latitudes are very large compared to the particle energies. However, some efforts5-8 have been made to work out plausible mechanisms for the access of charged solar particles to the low latitudes and the result of the present investigation sheds light on these theoretical studies.

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