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Observations of a geomagnetic $SI^+ - SI^-$ pair and associated solar wind fluctuations

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Abstract. We report a pair of oppositely directed sudden impulses (SI), in the geomagnetic field (ΔX), at ground stations, called $SI^+ - SI^-$ pairs, that occurred between 1835 UT and 2300 UT on 23 April 1998. The $SI^+ - SI^-$ pair, was well correlated with corresponding variations in the solar wind density, while solar wind velocity and the southward component of the interplanetary magnetic field (Bz) did not show any correspondence. This event had no source on the visible solar disk but was associated with a rear-side fast partial halo coronal mass ejection (CME) and an optically occulted M1.4 class solar flare behind the west limb. This event was unique in that one could clearly identify variations in ΔX at ground stations with solar wind parameters.

Keywords. Interplanetary shocks, Sun: solar wind and Sun: magnetic fields.

1. Introduction

It is well known that the driver of most space weather events at 1 AU are a result of the interplay of solar differential rotation with solar photospheric magnetic fields swept out into the solar wind to form the interplanetary magnetic field. Sudden impulses in H, called $SI^+ - SI^-$ pairs were hypothesized to be caused by the arrival, at 1 AU, of a pair of interplanetary shocks, with one being a forward shock and the other a reverse shock, convected towards the earth by the solar wind. In addition, worldwide occurrences of SI pairs have been reported in the past and it has been suggested that they are associated with solar disturbance and interplanetary shocks that are driven at highly oblique angles to the wind streaming direction. We have made a detailed study of one such $SI^+ - SI^-$ pair observed on 23 April 1998 (Rastogi *et al.*, 2010 and references therein).

2. Result and Discussion

An SI pair was observed at three Indian geo-magnetic observatories, Gulmarg, Alibag and Trivandrum, between 1835 and 2300 UT on 23-24 April 1998 as evident from, the bottom-most panel, Figure 1 showing the tracings of H magnetograms marked as ΔX. Also, the corresponding changes in the solar wind velocity, IMF-Bz, the soalr wind density and the symmetrical H field (SYM/H) are shown in the top four panels of Fig.1. The SYM/H field, representing the mean variation of H at all mid-latitude stations around the world, too had similar variations as the H at Indian stations implying that the SI pair event was a global event.

The ΔX, after the SI^+ at 1835 UT, had shown a gradual decrease till 2000 UT due to the prompt penetration of the electric field when IMF-Bz was negative during that period. Again, at around 2000 UT, the ΔX increased suddenly becuase of the overshielding effect as southward IMF-Bz turned to northward at this instant. But the fluctuations in ΔX between 2130-2200 UT were correlated with the solar wind density rather than with the IMF-Bz or the solar wind velocity. Similarily, it can be seen that the SI^+ at 1835 UT and

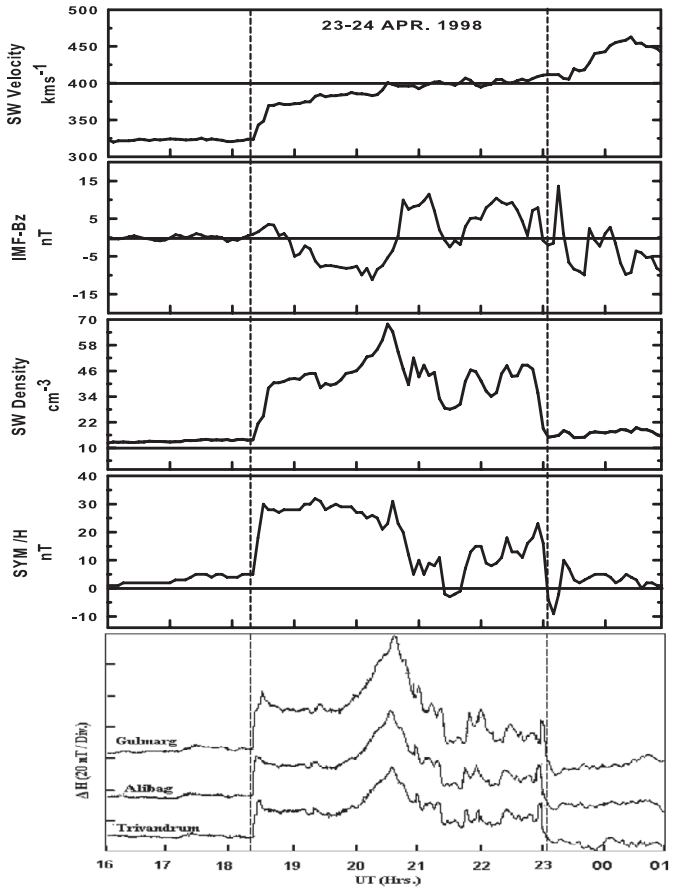

Figure 1. The top four panels respectivley show the variations of the solar wind velocity, Bz, the soalr wind density and the symmetrical H Field on 23–24 April 1998 while the variations of the H field at Indian geomagnetic stations are shown in the bottom most panel. The pair of dashed vertically oriented parallel lines in all panels demarcate the times 1835 UT and 2300 UT corresponding to the times of the SI^+ and the SI^- impulse pair in the H field respectively.

SI^- at 2300 UT were respectively associated with a sudden increase and decrease of the solar wind density causing a sudden pressure on the magnetosphere. The solar source of this event was traced to a fast ($\sim$1850 km s^{-1}) rearside partial halo CME in association with an optically occulted GOES M1.4 class flare on 20 April 1998. Since this was a rear-side CME the shock front would have been in a direction away from the earth and could be convected towards the earth by the solar wind. The reverse shock front would travel much slower than the velocity of shock in the flare direction, hence the flare and the CME provided the forward and reverse shocks causing the SI^+ and SI^- pair. This solar event, thus, showed signatures of all mechanisms involving solar – magnetosphere – ionosphere coupling within 4 to 5 hours.

References

Rastogi, R. G., Janardhan, P., Ahmed, K., Das, A. C., & Susanta Kumar Bisoi 2010, *J. Geophys. Res.*, 115, A12110.

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