Asteroids, Comets, Meteors 1991, pp. 321-324
Lunar and Planetary Institute, Houston, 1992

DISTURBANCES OF BOTH COMETARY AND EARTH'S MAGNETOSPHERES EXCITED BY SINGLE SOLAR FLARES

I. Konno[1], T. Saito[2], Y. Kozuka[2], K. Nishioka[3], M. Saito[4], and T. Takahashi[2]

1. Southwest Research Institute, USA 2. Geophysical Institute, Tohoku University, Japan 3. Olympus Optical Co. Ltd., Japan 4. Saito Astronomical Observatory, Japan

INTRODUCTION

In the solar wind a comet plays the role of a windvane that moves three-dimensionally in the heliomagnetosphere. Among the solar system bodies, only comets have a wide range of inclination angles of their orbital planes to the ecliptic plane ranging from 0° to 90°. Therefore, observations of cometary plasma tails are useful in probing the heliomagnetospheric conditions in the high heliolatitudinal region. A comet can be compared to a polar-orbiting probe encircling the Sun. We will introduce two rare cases in which the magnetospheres of both the comet and the Earth are disturbed by a single solar flare.

DISTURBANCES OF COMET P/BRORSEN-METCALF AND THE EARTH

An outstanding disturbance of Comet P/Brorsen-Metcalf was observed on August 13, 1989. Figure 1 shows the comet in eight panels of the identical portion of the sky from 17h17m to 18h51m UT. An outstanding disconnection event (DE) took place and a plasmoid was swept away at very high speed. About half a day later, the Earth's magnetosphere suffered a disturbance as inferred in Figure 2 that shows the geomagnetic variation of the horizontal component observed at the Onagawa Magnetic Observatory in Japan. Two storm sudden commencements (SCs) occurred succesively at 01h51m and 06h13m.

We surveyed many solar flares to find the sources of the two SCs of the magnetic storm at the Earth. Assuming that a solar flare gave rise to a shock front which propagated at a constant speed from the Sun to the Earth causing the SCs, the propagating speed for each of the flares was calculated. If we assume that the possible flares are larger than 2B of importance in the central disk with the propagating speed of 1000 ± 100 km s^{-1}, the two flares at 07h56m and 13h57m on August 12 are regarded to be the sources of the SCs.

Figure 3a and 3b show the relation of the positions between the Sun, the Earth, and P/Brorsen-Metcalf on August 13, 1989, on the meridian plane and the ecliptic plane, respectively. It is quite possible judging from the figure that the identical flare disturbed both the Earth's magnetosphere and the cometary magnetosphere. The probable propagating speed of the shock wave from the flare to the comet is either 1017 km s^{-1} or 1190 km s^{-1} (There are two possible source flares that occurred about the same time.)

It has been suggested by Niedner and Brandt (1978) that a DE is caused by a magnetic field line reconnection at the dayside associated with a sector boundary crossing. However, it is suggested, from observations, that a night-side reconnection associated with a rapid increase of a dynamic pressure caused by a high-speed stream is one of the causes of DEs (Russell et al., 1986; Saito et al., 1986). We assume that the DE in question was like an SC-triggered substorm (Saito et al., 1987) that starts usually within five minutes after a sudden increase of the dynamic pressure of the solar wind.

DISTURBANCES OF COMET OKAZAKI-LEVY-RUDENKO AND THE EARTH

Disturbances in Comet Okazaki-Levy-Rudenko were observed in Hokkaido, Japan, during about 19h~20h UT on November 16, 1989. The plasma tail suffered complex disturbances including a disconnection event as seen in Figure 4. Figure 5 shows a magnetogram obtained at the Onagawa Magnetic Observatory indicating the magnetic storm that commenced with an SC at 09h20m UT on November 17, 1989. The solar flare that occurred at 06h38m UT on November 15 is found to be the possible source for the magnetic storm considering the propagating speed of 825 km s^{-1} and the position of the flare. Figures 6a and 6b show the geometrical relation between the Sun, Earth, and Comet Okazaki-Levy-Rudenko on November 16, 1989, on the meridian plane and ecliptic plane, respectively. We conclude that a single solar flare again gave rise to the distrubances of the magnetospheres of both Comet O-L-R and the Earth. The propagating speed of the shock wave from the flare to the comet is about 740 km s^{-1}.

References

Niedner Jr., M.B. and Brandt J.C. (1978) Interplanetary gas XXIII. Plasma tail disconection events in comets: Evidence for magnetic field line reconnection at interplanetary sector boundaries?, Astrophys. J., 223, 655.

Russell C.T., Saunder M.A., and Phillips J.L. (1986) Near-tail reconnection as the cause of cometary tail disconnections, J. Geophys. Res., 91, 1417.

Saito T., Yumoto K., Hirao K., Saito K., Nakagawa T., and Smith E.J. (1986) A disturbance of the ion tail of comet Halley and the heliospheric structure as observed by Sakigake, Geophys. Res. Lett., 13, 821.

Saito T., Yumoto K., Hirao K., Minami S., Saito K., and Smith E. (1987) Structure and dynamics of the plasma tail of comet P/Halley I. Knot event on December 31, 1985, Astron. Astrophys., 187, 209.

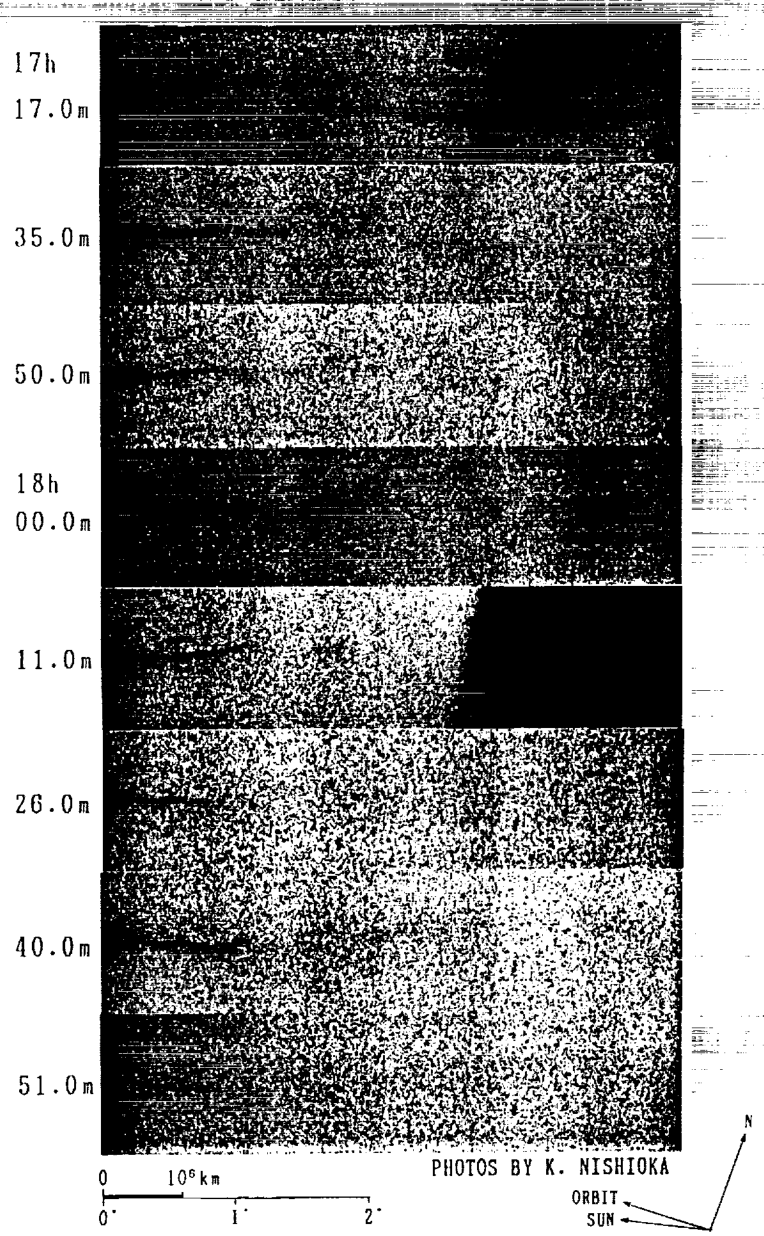


Fig. 1. – DE in Comet P/Brorsen-Metcalf on August 13, 1989 (UT).

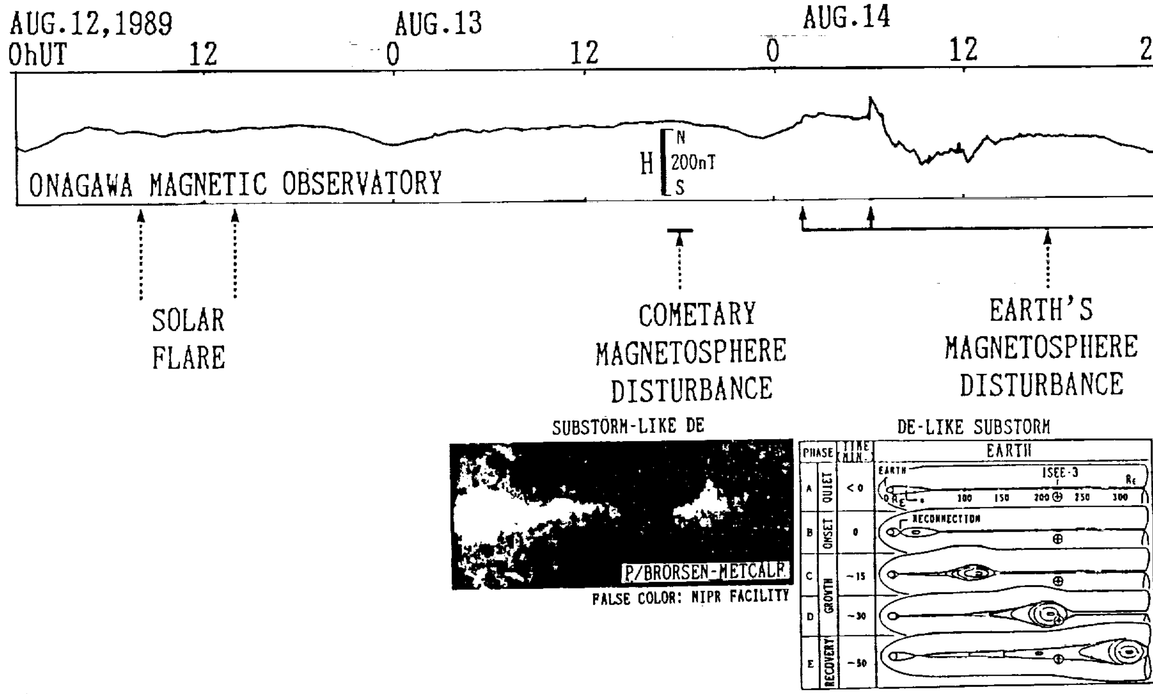


Fig. 2. – Geomegnetic variation of the horizontal component observed in Japan. Two storm sudden commencements occured on August 14, 1989.

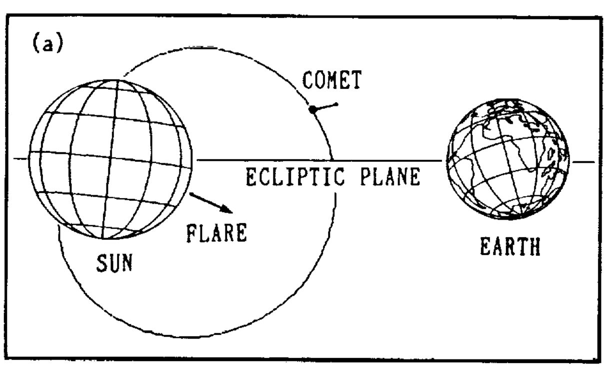
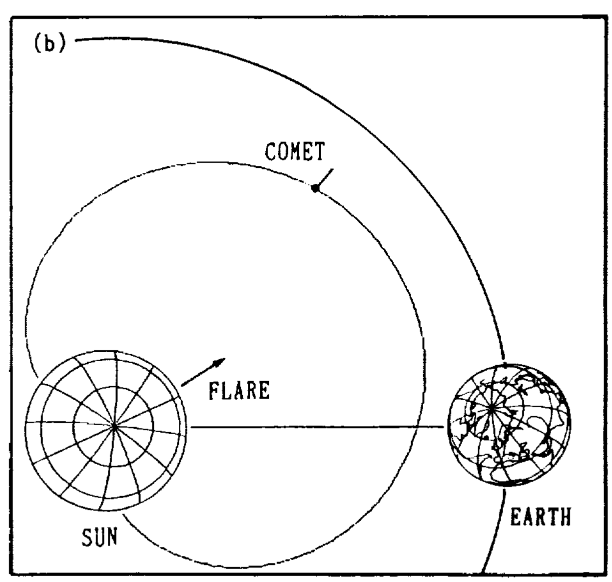


Fig. 3. – Geometrical relation between the Sun, the Earth and P/Brorsen-Metcalf on August 13, 1989 (UT).



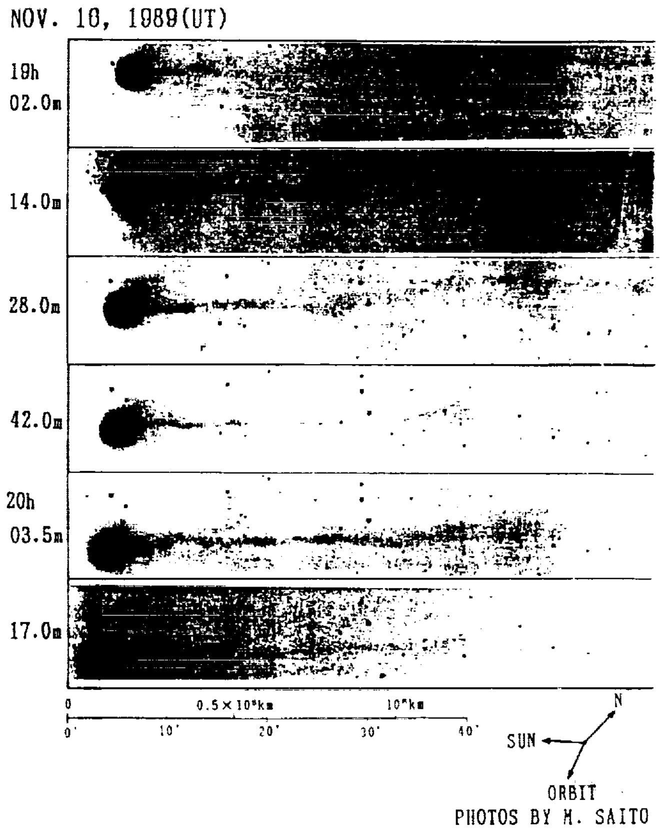


Fig. 4. – Disturbances of the plasma tail of Comet Okazaki-Levy-Rudenko on November 16, 1989 (UT).

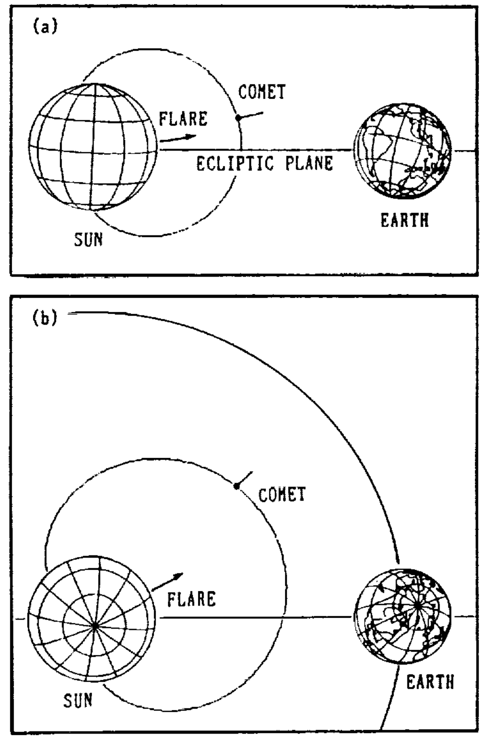


Fig. 6. – Geometrical relation between the Sun, the Earth and C/Okazaki-Levy-Rudenko on November 16, 1989 (UT).

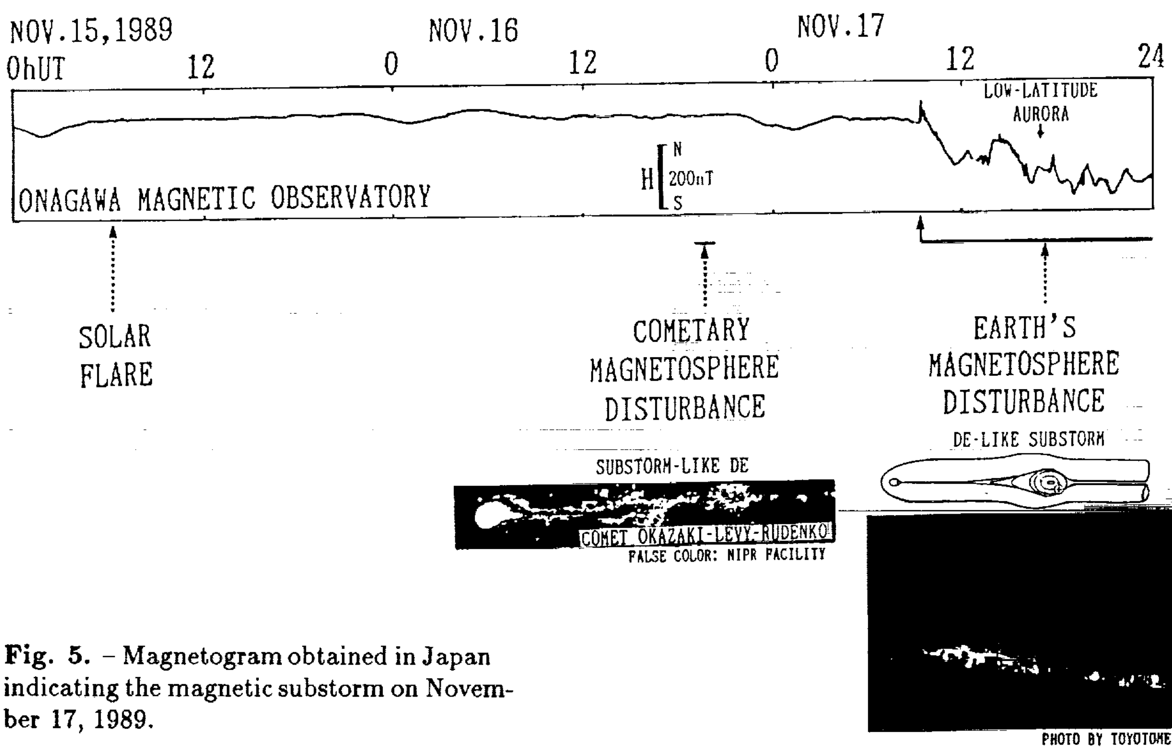


Fig. 5. – Magnetogram obtained in Japan indicating the magnetic substorm on November 17, 1989.