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Geomagnetic effect associated with X-ray flare from Sco X-1

THE effect on the night-time lower ionosphere of X radiation from celestial sources is a topic of some controversy[1–4]. An X-ray flare from Sco X-1 has been shown to have a daytime effect on the ionosphere[5] and it has also been reported[6] that celestial X-ray sources have a nocturnal effect on the lower ionosphere in certain conditions. Galactic X-ray ionisation has been shown[7–9] to affect night-time geomagnetic field components.

We have examined the possibility that an X-ray flare from Sco X-1, detected in the course of a balloon flight on October 15, 1967 at Mildura (34° 12′S; 142° 6′E)[10], had a daytime geomagnetic effect. We observed a conspicuous perturbation in the form of an increase in the horizontal component of the magnetic field observed at the equatorial station at Kodaikanal (10° 14′N, 77° 28′E).

On October 15, 1967, Sco X-1 flared up at about 0700 UT, reaching a maximum in less than 10 min and then decreasing during the next 20 min (Fig. 1). The perturbation in the horizontal component of the magnetic field started around 0715 UT, and rose to a maximum at 0725 UT (an increase in the H component of about 14 γ), about 16 min after the flare had reached a maximum at around 0710 UT. Unfortunately, a small optical solar flare occurred about 15 min before the Sco X-1 flare, during the period 0647–0710 UT, with a maximum at 0650 UT.

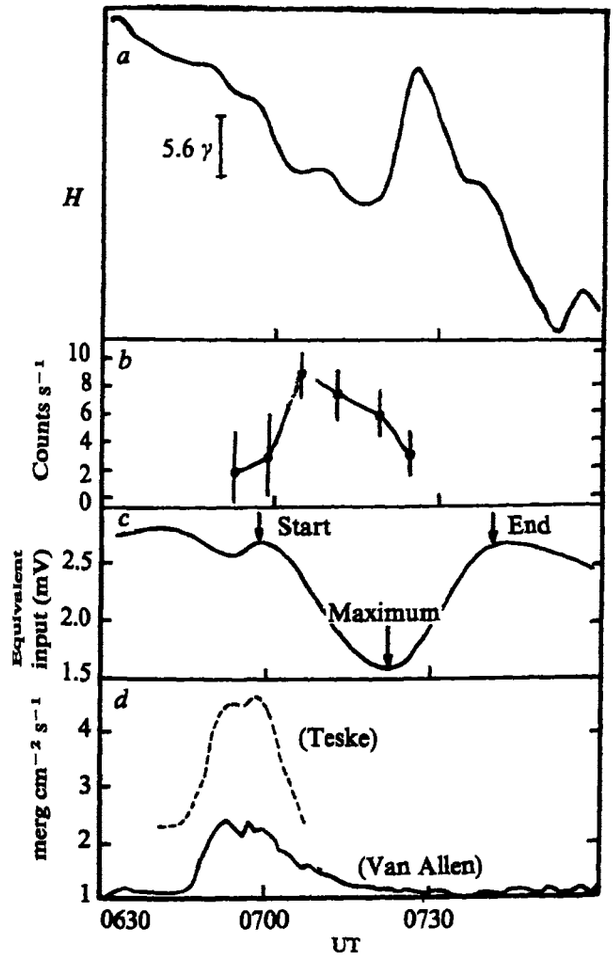

Fig. 1 Kodaikanal, October 15, 1967; temporal variations in: *a*, the horizontal component, H of the magnetic field at Kodaikanal; *b*, 20–30 keV X-ray counts from Sco XR-1 (ref. 10); *c*, the field strength (164 kHz) over the Tashkent–Delhi path (after Ramanamurthy *et al.*[5]); *d*, the solar X-ray flux 2–12 Å (Van Allen) and 8–12 Å (Teske), (after Ramanamurthy *et al.*[5]).

In view of this, we have examined the possibility that the observed geomagnetic effect was caused by this solar flare, using the available solar X-ray flux data for this event. The procedure followed is similar to that adopted by Ramanamurthy *et al.*[5]. Solar X-ray flux data show a small burst in the 8–12 Å band during the period 0640–0713 UT but it is considered unlikely that it produced a solar flare effect (SFE), (geomagnetic crochet) as its amplitude is below the threshold value. Van Allen's data from Explorer 35 show a flare (with a flux enhancement of 2.3) which began at about 0640 UT, reached a maximum at about 0653 UT and ended at about 0730 UT. An earlier study made by us showed that the relaxation time of the SFE (geomagnetic crochet) with reference to the solar X-ray flare (1–20 Å) ranges from −10 to +22 min (with an average value of 4.0 min for the 1–8 Å band and 1.4 min for the 8–20 Å band). Thus, the observed time lag of about 33 min between the solar X-ray flare (2–12 Å) maximum and that of the observed geomagnetic effect is well outside the range of relaxation times for geomagnetic solar flare effects (SFE or crochet events).

The possible daytime geomagnetic effect of Sco X-1 is considered more interesting than the nocturnal effect reported earlier, as during the day the rate of ion production resulting from the Sco X-1 X-ray flux has to compete with the rate resulting from the solar X-ray flux and L_α besides that resulting from galactic cosmic rays. An estimation of the production rates attributable to Sco X-1, L_α and galactic cosmic rays indicates that the rates of production attributable to the X-ray source are comparable with those attributable to cosmic rays and L_α at levels below about 70 km (ref. 5). So the observed geomagnetic effect could be attributable to X-ray flux enhancement (1–20 Å), as during an SFE (crochet) the region of enhanced conductivity lies in the D-region[11–14].

A sudden impulse (SI) was reported on October 15, 1967 at 0724 UT from two stations, SO and HL and an SSC was reported from station SU (Solar-Geophysical Data ESSA/NOAA). In view of the circumstantial evidence presented here, however, we do not consider the observed geomagnetic perturbation at Kodaikanal as an SI or an SSC but as a genuine effect of the X-ray flare from Sco X-1.

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1 Edwards, P. J., Burtt, G. J., and Know, F., *Nature*, 222, 1053–1054 (1969).
2 Ananthakrishnan, S., and Ramanathan, K. R., *Nature*, 223, 488–489 (1969).
3 Chilton, C. J., and Crary, J. H., *Radio Sci.*, 6, 699–708 (1971).
4 Burgess, B., and Jones, T. B., *Nature*, 224, 680–681 (1969).
5 Ramanamurthy, Y. V., Mitra, A. P., and Jain, V. C., *J. atmos. terr. Phys.*, 32, 1721–1726 (1970).
6 Mitra, A. P., and Ramanamurthy, Y. V., *Radio Sci.*, 7, 67–72 (1972).
7 Campbell, W. H., Matsushita, S., and Bunder, B. K., *Radio Sci.*, 6, 165–170 (1971).
8 Campbell, W. H., *Planet. Space Sci.*, 20, 61–71 (1972).
9 Murthy, A. V. S., and Yacob, A., *Planet. Space. Sci.*, 22, 1583–1584 (1974).
10 Lewin, W. H. G., Clark, G. W., and Smith, W. B., *Astrophys. J. Lett.*, 152, L55–61 (1968).
11 Sastri, H. J., and Murthy, B. S., *Solar Phys.* (in the press).
12 Volland, H., and Taubenheim, J., *J. atmos. terr. Phys.*, 12, 258 (1958).
13 Veldkamps, J., and Van Sabben, D., *J. atmos. terr. Phys.*, 18, 192 (1960).
14 Pinter, S., *Bull. astr. Insts Col.*, 18, 274–281 (1967).

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