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Explorer XII measurements of the intensity of interplanetary protons of energy greater than 3 Mev provide a method of investigating long-lived solar plasma streams. On two occasions (27 October and 1 December 1961) we observed an increase of the intensity of these particles. The increases were unaccompanied by a solar flare but occurred at the beginning of a magnetic storm and Forbush decrease near the time of central meridian passage of a region responsible for a flare and a solar proton event during the previous solar rotation. These increases were very small and probably could not have been detected with riometers. Chapman and Ferraro[1] have shown that a stream of neutral plasma emitted from the sun could cause magnetic storms. The recurrence of small magnetic storms over many 27-day cycles of solar rotation led Bartels[2] to postulate that such streams were continuously emitted from long-lived regions on the sun which he called M regions. Recent Mariner II measurements[3] have shown the existence of solar plasma with a 27-day structure. Magnetic fields carried by solar plasma are thought to be responsible for Forbush decreases of cosmic ray intensity which often occur during magnetic storms. Although no direct measurements of such streams have been made on Explorer XII by our detectors, the intensity increases of these $>$ 3 Mev protons require streams of plasma and magnetic fields to carry the protons from the vicinity of the sun or to accelerate them locally or to trap interplanetary solar protons remaining from a previous solar event. We feel that the presence of protons of a few Mev in the plasma does not imply that they are an intrinsic feature of the plasma but rather that it is a consequence of latent trapping regions in the plasma being filled with solar protons from a preceding event.

The instruments on Explorer XII, designed to study galactic and solar cosmic rays, have been described[4]. The measurements reported here were made while the satellite was outside the magnetosphere on the sun-lit side of the earth.

Figure 1 shows the intensity of interplanetary protons of energy greater than 3 Mev, whenever it was above the quiet-time value, from 30 September to 28 October 1961. A class 3 solar flare on 28 September 1961 initiated a solar proton event[4]. Two days later, long after the solar proton intensity had passed through a maximum, there was an increase to a level about 10 times greater than that of the solar proton maximum. At the same time there was a series of geophysical disturbances (including a magnetic storm with a sudden commencement and a mid-latitude auroral display) and a Forbush decrease of relativistic protons observed both by Explorer XII and by neutron monitors. These events indicated the arrival of a stream of solar plasma carrying a magnetic field. The enhanced proton intensity and the geophysical disturbances had subsided by about 7 October. The proton intensity remained at its normal quiet-time value from 7 October until 27 October when there was again an increase in the proton intensity accompanied by a Forbush decrease and geomagnetic storms. (Table 1 summarizes these events.)

The intensity increase on 27 October is unlike a solar proton event: it is not immediately preceded by a solar disturbance and the time constants of rise and decay are only a few hours. Further, the arrival times are not a function of proton velocity since the shapes of the differential kinetic energy spectra at onset and at maximum intensity are nearly the same, both having a power-law exponent between -4 and -5 in the range 3 to 10 Mev. We suggest that the active region of the sun responsible for the 28 September flare was the origin of a long-lived plasma stream that we encountered on 27 October, a full rotation of the sun after 30 September. If the continuous emission of this long-lived stream began during the active life of the region either on or before 28 September, the > 3 Mev proton intensity increase on 30 September was also caused by an encounter with that stream, but to ascribe the 30 September and 27 October proton increases to an identical phenomenon may be an over-simplification, since the earlier event may have been a result of a different and transient phenomenon (such as the shock wave postulated by Parker[5] or the magnetic bottle postulated by Gold[6]) caused by the solar activity of 28 September. During the rotation of the sun following October 27, the region stopped emitting plasma since neither our records nor geophysical observations show an event 27 days later in November.

It seems likely that our observations of 27 October are closely related to the phenomenon of R-rays as proposed by Müstel[7,8]. Müstel considers R-rays which are thin and filamentary extensions of the outer corona above activity centers to be responsible for recurrent magnetic storms. Figure 2 is a schematic drawing made by Müstel showing these R-rays. The fine structure in the proton intensity increase on 27 October may have been a direct consequence of the filamentary structure of the rays.

The second of the two events we wish to mention occurred on 1 December 1961. It is similar to that of 27 October and the relevant sequence of events is also outlined in Table 1. On 10 November 1961 a flare accompanied by Type IV emission occurred on the extreme west limb of the sun and initiated a solar proton event which was observed by Explorer XII. No magnetic storm, Forbush decrease or > 3 Mev proton increase was seen after the usual one-to three-day plasma transit time from the sun to the earth. Three weeks later on 1 December 1961, after 3/4 of a solar rotation, there was a Forbush decrease, a magnetic storm and a >3 Mev proton event similar to that of 27 October indicating the arrival of a solar plasma stream. The occurrence of the event of 1 December closely coincided with the central meridian passage of the active region which produced the flare on 10 November. This event again substantiates the picture of a long-lived plasma stream emanating from an active region of the sun but in this case the timing was different owing to the different position of the parent flare on the sun.

There is another occurrence which could be the same phenomenon. On 7 September 1961 a solar proton event having an anomalously slow intensity decay was observed by Explorer XII, the details of which will be reported in a later paper. There was no observation at that time of a large flare or of Type IV emission which can definitely be associated with this event and there was no geophysical disturbance two days later. Eleven days later on 18 September there was a small increase of the intensity of >3 Mev protons similar in spectrum to those of 27 October and 1 December and unaccompanied by a flare. We speculate from these observations that the flare responsible for the solar proton event of 7 September occurred on the remote side of the sun and that the increase on 18 September was the same phenomenon as that observed on 27 October and 1 December. In contrast to this view Skerjanec et al.[9] attribute the 7 September event to a solar radio noise storm on 6 September occurring in a plage region which was 40 degrees west on 6 September and which was the origin of a solar cosmic ray event on 10 September when this plage region reached the west limb of the sun.

TABLE 1

Solar Flare: (class 3 or 3+) Time: 2202 UT, 28 September 1961 Type IV Radio Emission: 2214 UT Location: 15° N, 29° E	Solar Flare: (class > 1) Time: 1435 UT, 10 November 1961 Type IV Radio Emission: 1440 UT Location: 19° N, $\approx 90^{\circ}$ W
Forbush Decrease: Duration: 30 Sept. to $\approx$ 5 Oct. Maximum Amplitude: Explorer XII: 8% Deep River: 5% Geomagnetic Storm: Duration: 30 Sept. to $\approx$ 6 Oct. SC: 2108 UT, 30 September Main Phase: 170 gamma > 3 Mev Protons at Explorer XII: Onset Time: 1930 UT, 30 September Max. Intensity: $2 \times 10^{7}/m^{2}$ s st	(No effects of two days delay)

Recurrence Phenomena Associated with Above Events

Forbush Decrease: Duration: 28 Oct. to $\approx$ 1 Nov. Maximum Amplitude: Explorer XII: 3% Deep River: 2% Geomagnetic Storms: Duration: 26 to 27 October SC: 1940 UT, 26 October Main Phase: 70 gamma Duration: 28 Oct. to $\approx$ 1 Nov. SC: 0820 UT, 28 October Main Phase: 280 gamma > 3 Mev Protons at Explorer XII: Onset Time: between 26 and 27 Oct. Max. Intensity: $2 \times 10^{5}/m^{2}$ s st	Forbush Decrease: Duration: 1 Dec. to $\approx$ 4 Dec. Maximum Amplitude: Explorer XII: 8% Deep River: 4% Geomagnetic Storm: Duration: 1 Dec. to $\approx$ 4 Dec. Main Phase: 145 gamma > 3 Mev Protons at Explorer XII: Onset Time: before 0300 UT, 1 Dec. Max. Intensity: $> 1.6 \times 10^{5}/m^{2}$ s st

FIGURE CAPTIONS

Fig. 1. Intensity of > 3 Mev protons between 30 September and 28 October 1961: (Note that the time scales before and after the period during which the intensity remained at a quiet-time value are different).

Fig. 2. Schematic drawing of R-rays after Müstel[8].

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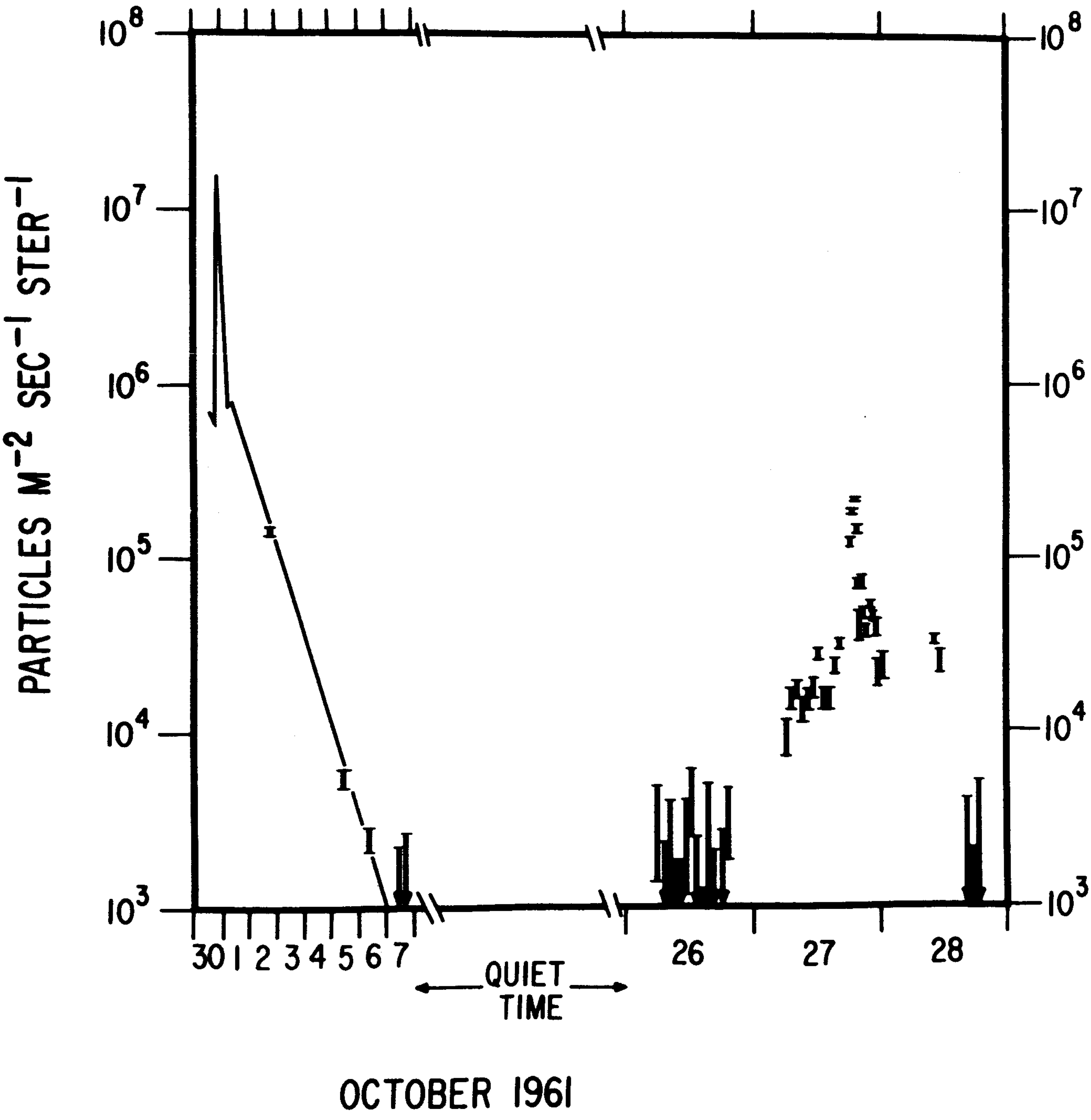

PARTICLES M^{-2} SEC^{-1} $STER^{-1}$
10^8
10^7
10^6
10^5
10^4
10^3
30 1 2 3 4 5 6 7
QUIET TIME
26
27
28
OCTOBER 1961

FIG. 1

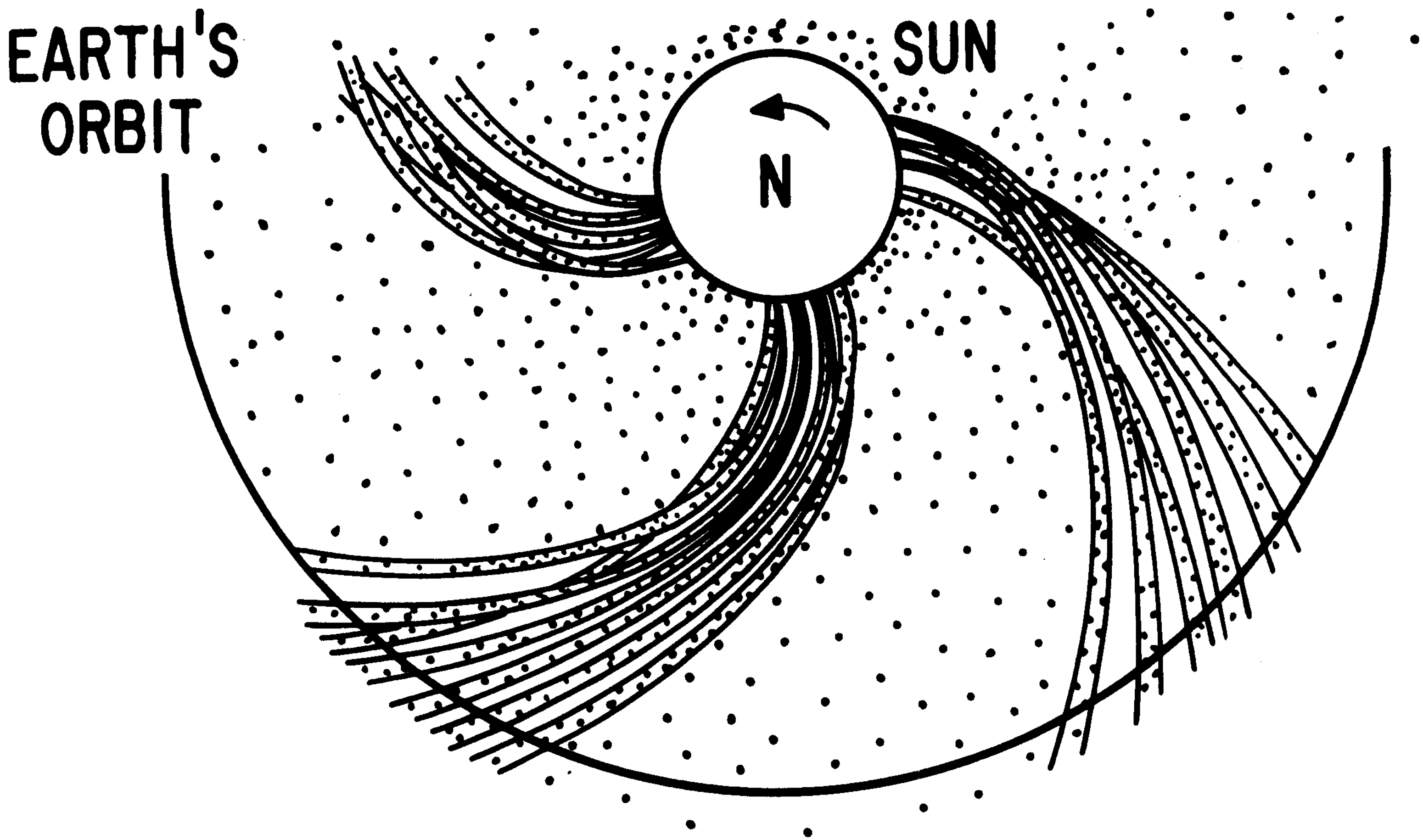

FIG. 2