THE SOLAR PARTICLE EVENTS OF
MAY 23 AND MAY 28, 1967

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Abstract. McMath plage region 8818 passed over the visible solar disk on May 17-31, 1967. It was very active from its first appearance on the Eastern limb, several times producing bright optical flares and hard X-ray emission, accompanied by intense type II, type IV and centimeter radio bursts. Nevertheless, no solar particles could be detected near the earth until the evening of May 23, when three bright flares were observed in close succession at 25°-28° E. During the following build-up of the solar particle flux over 36 hours, the galactic cosmic ray flux > 1 GeV decreased gradually by about 5%. The flux of solar particles decreased in two steps on May 25, both accompanied by decreases in the equatorial geomagnetic field. These field depressions are attributed to storm plasma ejected from the parent flare of the May 23 particle event. The propagation of solar particles from May 23 on thus appears to be strongly affected by storm plasma from the parent flare of the May 23 event, without any indications of solar particles being trapped in that plasma.

A later particle event early on May 28 was also associated with a bright flare in McMath region 8818, at 33° W. This event displayed a rapid build-up, with electrons arriving first, and an exponential decay. A smooth proton peak, 20 min wide, was detected on May 30 closely associated with an SSC attributed to plasma ejection from the parent flare of the May 28 event.

Between the geomagnetic storms beginning on May 25 and May 30 an anomalous daily variation was observed in the cosmic ray flux > 1 GeV, the time of maximum falling 7-10 hours earlier than normal. Storm time increases in the flux of galactic cosmic rays were seen on May 26 when the equatorial geomagnetic field was depressed by more than 400 γ. Low latitude auroras were also observed during that time.

1. Introduction

Many phenomena observed at the earth or on space probes in the near interplanetary space can be traced back to an impulsive release of energy in some part of the solar atmosphere. Several of these phenomena display in one way or the other a strong dependence on the heliographic position of the center of the triggering solar activity.

In a statistical study of a great many geomagnetic storms, AKASOFU and YOSHIDA (1967) have claimed that the fast plasma, which is ejected from the sun at times of enhanced activity and subsequently causes geomagnetic storms, is confined largely to a rather narrow jet, the main phase decrease of geomagnetic storms being roughly proportional to \( \text{sech}^2 \Omega \), where \( \Omega \) is the angular distance between the point of plasma ejection and the subterrestrial point on the sun. On the other hand, the same authors have also pointed out that certain effects of the enhanced plasma flow extend over a very large solid angle since storm sudden commencements can be observed even...
when the associated flares are located near the Eastern or Western limb of the solar disk. In such cases the sudden commencements are observed to be comparatively weak.

If the probability of observing a strong sudden commencement followed by a severe magnetic storm is high for flares near the center of the solar disk many other phenomena occur preferentially after Eastern, or sometimes central, flares. In contrast to flares far over to the West, such flares produce prominent Forbush decreases (Sinno, 1962; Haurwitz et al., 1965) and cosmic ray decreases of long duration (Sinno, 1962). Strong polar cap absorption of the type associated with storm sudden commencements also belongs to this category of events. The latter observation is due to Haurwitz et al. (1965) who proposed an asymmetric plasma cloud model to explain their observations. Lindgren (1968) has suggested that the reversal of the streaming direction of cosmic rays > 1 GeV which has been observed in a few cases, almost exclusively in connection with Forbush decreases, is related to the ejection of storm plasma from flares well over to the East.

In contrast to severe geomagnetic storms and large Forbush decreases, most energetic solar particle events have their parent flares in the Western solar hemisphere. Studies of the propagation of such particles from the sun to detectors at or near the Earth have shown that these particles are guided away from the source or storage region along the interplanetary magnetic field lines, particles from ~60°W being easiest to observe at the earth (McCracken, 1962; Lin and Anderson, 1967; McCracken et al., 1967). During simultaneous measurements at the earth and on Mariner IV (O’Gallagher and Simpson, 1966) a particle event was detected on IMP-3 close to the earth which could not be observed on Mariner IV, at that time 40° further to the East. The parent flare was seen at ~75°W.

The purpose of the present paper is to describe two solar particle events which began on May 23 and May 28, 1967, and related solar and terrestrial phenomena. The two May events and some of the associated phenomena offer several possibilities to study some of the East-West effects summarized above and also effects arising from interactions between diffusing energetic solar particles and advancing plasma fronts. In the discussion of these effects, we use information from several other solar particle events in order to give a broader background for conclusions.

2. Optical Flares, Radio Bursts and Geomagnetic Disturbances

The particle events starting on May 23 and May 28, 1967 exhibit rather different characteristics. In particular the build-up and decay characteristics (Figure 1) are quite different. Both events were associated with optical flares in McMath plage region 8818, the former event apparently being caused by a flare, or possibly several flares, at 25°–28°E, the latter by a flare at 33°W.

To better understand the differences between these two particle events we describe in detail the solar activity and also the magnetic storms and cosmic ray effects at energies >1 GeV observed at the earth. Since the solar activity was concentrated in McMath region 8818 during the second half of May, 1967 we first describe the