SATELLITE OBSERVATIONS OF THE OUTER CORONA NEAR SUNSPOT MAXIMUM

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Abstract: This paper shows the first satellite observations of the Sun's white light corona (2.6 $R_\odot$ - 10.0 $R_\odot$) during the active phase of a sunspot cycle. Since March 28, 1979, these observations have been obtained routinely with a spatial resolution of 1.25 arc min and a repetition rate of 10 minutes during the one-hour sunlit portion of each 97-minute satellite orbital period. As an illustration of these new observations, we show the coronal changes associated with the great mass ejection of May 8, 1979.

Satellite observations of the Sun's white light corona began during 1971-1973 with the Naval Research Laboratory's coronagraph on OSO-7 (Howard et al., 1975, Koomen et al., 1975) and were extended into 1973-1974 with the High Altitude Observatory's coronagraph in the Skylab Apollo Telescope Mount (MacQueen et al., 1974). This paper presents the first observations obtained with a new NRL coronagraph called Solwind that is currently operating on the US Department of Defense Space Test Program Satellite P78-1 in a noon-midnight polar orbit. Like the previous NRL instrument, the new one has a spatial resolution of 1.25 arc min and a field of view that extends from the occulting disk near 2.6 $R_\odot$ to an outer limit of 10.0 $R_\odot$. However, unlike the previous instrument which could obtain full-field images only once per satellite orbit, the Solwind coronagraph routinely obtains full-field images at a repetition rate of 10 minutes during the one-hour sunlit portion of each 97-minute satellite orbital period. The Solwind observations are expected to continue at least into early 1980 when another HAO white light coronagraph (MacQueen et al., 1979) will begin operation from the NASA Solar Maximum Mission Satellite (Bohlin, 1979).

Figure 1 compares four coronal images obtained with the Solwind instrument on May 8-9, 1979. In each case, the outer limit of the field of view has been masked down to approximately 8.0 $R_\odot$. The white area in the center of the May 9 image indicates the size of the Sun's photospheric disk. Eccentric circular annuli near 4-5 $R_\odot$ and 7-8 $R_\odot$ are analyzers for the linear polarization that one expects from Thomson-scattered radiation from electrons in the plane of the sky.

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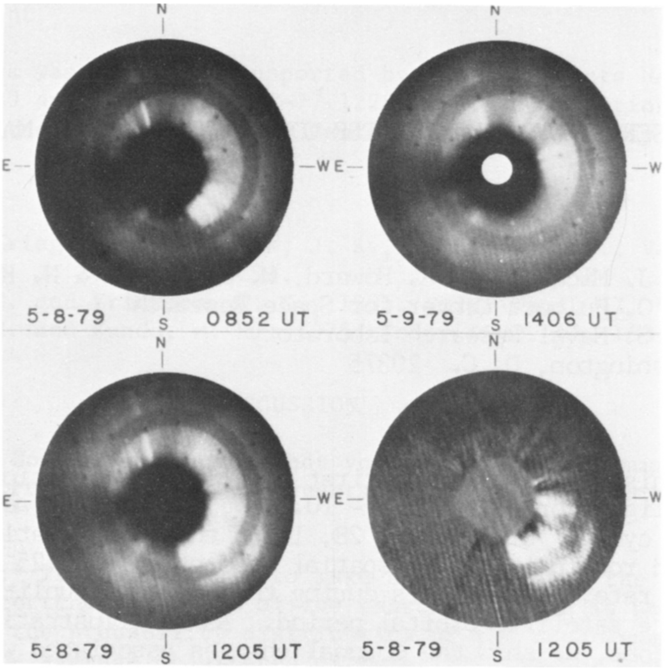

Fig. 1: Coronal images before, during, and after the mass ejection of May 8, 1979. The image at the lower right is the difference between the frames at 1205 UT and 0852 UT. The white area at the center of the May 9 image indicates the approximate size of the photospheric disk.

At 0852 UT on May 8, a number of bright streamers are visible extending radially across most of the field of view. One lies only 15° east of north. Such high-latitude streamers typically occur near the peak of the sunspot cycle and were not observed during the declining phase by the OSO-7 and Skylab coronagraphs. Comparisons between groundbased eclipse photographs of the inner corona and rocket-based photographs of the outer corona near the peak of the previous cycle suggest that at least some of these high-latitude features are the tops of helmet streamers (cf. Bohlin et al., 1971). Although the image at 1406 UT on May 9 has been printed with a lighter background than the image at 0852 UT on May 8, the high-latitude streamer is still visible whereas the bright streamers that were in the southwest quadrant have disappeared. This disappearance accompanied the coronal transient that is visible at 1205 UT on May 8 in the lower panel of Figure 1.

When the image at 0852 UT is subtracted from the image at 1205 UT, one obtains the "difference" image in the lower right panel. In the southwest, not only do the very bright structures indicate the newly ejected coronal mass, but the dark region at $3R_\odot$ just beyond the occulting disk indicates the coronal depletion corresponding to the disappearance of the previously existing streamers. At this preliminary stage of our

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data analysis, we do not know whether the faint structures in the south-east and north indicate real changes of individual streamers or the lack of perfect cancellation. (We shall see in Figure 2 that some difference images show imperfections resulting from the obvious misalignment of the subtracted frames).

Figure 2 shows a sequence of difference images during the evolution of the transient. In each case, the image at 0852 UT has been subtracted from an image at the indicated time. Although some spurious signals are obvious, the outward expansion of the transient is clearly visible. The

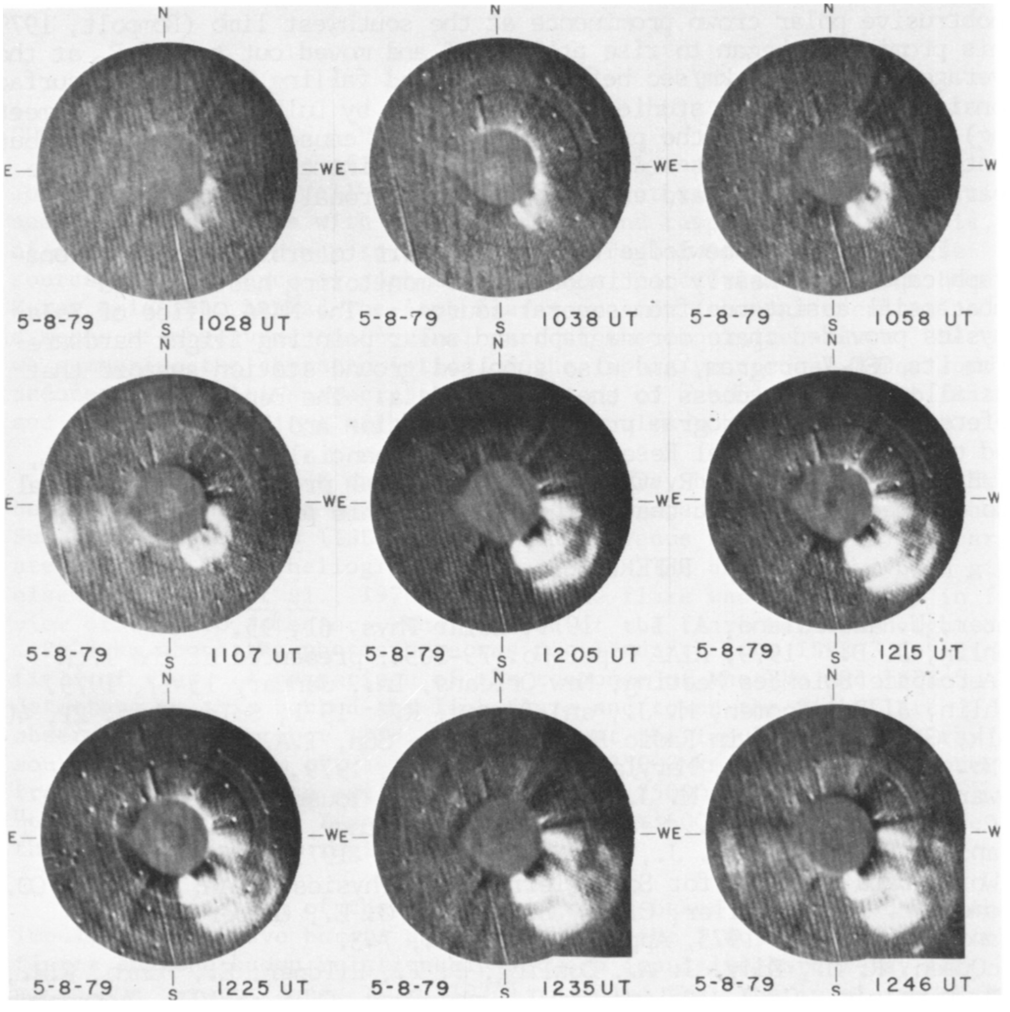

Fig. 2: Difference images (all relative to the frame at 0852 UT) during the May 8 transient. In the last two frames, the 8.0 $R_\odot$ mask has been cut to show the corona to the instrumental limit of 10.0 $R_\odot$.

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leading edge of the ejected mass moves at roughly 500 km/sec across the field of view and the coronal depletion at ~3 $R_\odot$ became visible at 1205 UT. In addition, one can see the expansion and outward motion of a "hole" within the bright transient itself. Toward the end of this sequence, this feature is visible in the northwest part of the transient as a gray area approximately 2.7 $R_\odot$ in diameter. Finally, we note in Figure 1 that no evidence of the transient is visible at 1406 UT on May 9. This lack of remnants is unusual according to Anzer and Poland (1971) who found that during the Skylab mission transient "legs" usually remained visible for 2-3 days following each event.

This transient was associated with the eruption of a relatively unobtrusive polar crown prominence at the southwest limb (Rompolt, 1979). This prominence began to rise at 0815 UT and moved out to 1.5 $R_\odot$ at the average speed of 40 km/sec before fading and falling back to the surface. Consistent with other studies (as summarized by Dulk, 1980 at this meeting), we suppose that the prominence did not "cause" the transient, but that both the transient and the eruptive prominence resulted from the rearrangement and outward expansion of the coronal magnetic field.

Finally, we acknowledge that this effort to orbit a small coronagraph capable of nearly continuous solar monitoring has received substantial assistance from several sources. The NASA Office of Solar Physics provided spare coronagraph and solar pointing flight hardware from its OSO-7 program, and also supplied ground station support that has allowed quick access to the Solwind data. The Department of Defense Space Test Program provided integration and launch support and the Office of Naval Research provided financial support. At NRL, F. Harlow, D. Roberts, R. Chaimson, and R. Seal provided the technical and engineering support that helped to make this project a success.

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