THE SPEEDS OF CORONAL MASS EJECTION EVENTS

J. T. GOSLING
University of California, Los Alamos Scientific Laboratory, Los Alamos, N.M. 87545, U.S.A.

and

E. HILDNER, R. M. MacQUEEN, R. H. MUNRO.
A. I. POLAND and C. L. ROSS
High Altitude Observatory, National Center for Atmospheric Research,* Boulder, Colo. 80302, U.S.A.

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Abstract. The outward speeds of mass ejection events observed with the white light coronagraph experiment on Skylab varied over a range extending from less than 100 km s\(^{-1}\) to greater than 1200 km s\(^{-1}\). For all events the average speed within the field of view of the experiment (1.75 to 6 solar radii) was 470 km s\(^{-1}\). Typically, flare associated events (Importance 1 or greater) traveled faster (775 km s\(^{-1}\)) than events associated with eruptive prominences (330 km s\(^{-1}\)); no flare associated event had a speed less than 360 km s\(^{-1}\), and only one eruptive prominence associated event had a speed greater than 600 km s\(^{-1}\). Speeds versus height profiles for a limited number of events indicate that the leading edges of the ejecta move outward with constant or increasing speeds.

Metric wavelength type II and IV radio bursts are associated only with events moving faster than about 400 km s\(^{-1}\); all but two events moving faster than 500 km s\(^{-1}\) produced either a type II or IV radio burst or both. This suggests that the characteristic speed with which MHD signals propagate in the lower (1.1 to 3 solar radii) corona, where metric wavelength bursts are generated, is about 400 to 500 km s\(^{-1}\). The fact that the fastest mass ejection events are almost always associated with flares and with metric wavelength type II and IV radio bursts explains why major shock wave disturbances in the solar wind at 1 AU are most often associated with these forms of solar activity rather than with eruptive prominences.

1. Introduction

The dynamic nature of the outer solar corona has been revealed in recent years by improved techniques of observing the corona from the ground (e.g., Smerd and Dulk, 1971; Dunn, 1971; DeMastus et al., 1973; Hansen et al., 1974) and from spacecraft (e.g., Stone, 1974; Stewart et al., 1974a, b; Koosten et al., 1974; MacQueen et al., 1974a; Gosling et al., 1974; Hildner et al., 1975a). Viewed in optical wavelengths, disturbances in the outer corona often take the form of mass ejections in which outward moving material (of the order of 10\(^{15}\)–10\(^{16}\) g) appears to escape from the Sun. Such events are commonly associated with other forms of solar activity, particularly eruptive prominences and (less frequently) flares accompanied by surges and sprays; about 30% of the time they generate metric wavelength type II and/or IV radio bursts (Gosling et al., 1974; Munro et al., 1976). Despite their association with eruptive prominences and flare sprays, coronal

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mass ejections are considerably larger than their Hα counterparts, travel at
different speeds, and consist primarily of material originally residing in the lower
corona (Hildner et al., 1975b; Poland and Munro, 1976). MHD bow waves form
around the material ejecta which compress the ambient corona ahead of the
ejecta and deflect the ambient corona from the ejecta’s outward path; at times
these bow waves can be detected by their effects on nearby coronal structures
(e.g., Gosling et al., 1974; Hildner et al., 1975a).

Speeds measured for coronal mass ejections already reported in the literature
vary from less than 100 km s\(^{-1}\) (Hildner et al., 1975b) to greater than 1200 km s\(^{-1}\)
(Stewart et al., 1975a); however, no systematic study of ejection speeds, their
variation with height, and their correlation with other forms of solar activity has
been reported. It is our purpose here to present the results of such a study for the
mass ejection events observed with the white light coronagraph experiment
aboard Skylab.

2. The Observations

A. General

The High Altitude Observatory’s white light coronagraph experiment on Skylab
was designed to observe photospheric light scattered by the K-(electron) and
F-(dust) coronal components within a 3.2 degree field of view centered on the Sun
in broad band (3700–7000 Å) white light. Sequences of pictures taken in both
polarized and unpolarized light were obtained throughout the 8 month mission.
Descriptions of the instrument and its operating modes have been published
elsewhere (MacQueen et al., 1974a,b).

An example of a mass ejection event observed by the coronagraph is shown in
Figure 1. This is one of several photographs taken on 27 October 1973 following
a large flare at N20 E55. At least sixty-six similar events (most of them not
flare-associated) were observed during the Skylab mission. The temporal coverage
obtained for these sixty-six major events varies widely. For seven events the
frequency of observations was sufficiently high that the speeds of the leading
edges of the ejections can be determined as functions of height in the solar
atmosphere. For nineteen events we have only enough photographs to determine
the average outward speed within the field of view of the instrument. For the
remainder of the sixty-six events usually no more than one sequence of photo-
graphs was obtained which shows the leading edge of the ejection. Lower limit
estimates of the speed can be obtained for twelve of these latter events based
upon the time lapse from either the previous sequence of photographs or from the
start of the suspected surface or limb event (e.g., flare or eruptive prominence).
No meaningful estimates can be obtained for the remaining twenty-eight major
events either because surface or limb associations are unknown or because the
time lapse between successive sequences of pictures was too long.

The leading edge of a mass ejection event is usually well defined (see, e.g.,
Figure 1), and its displacement with time can be readily measured to determine