ON THE ASSOCIATION BETWEEN CORONAL MASS EJECTIONS AND CORONAL HOLES

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ABSTRACT. The coronal mass ejection (CME) data and the data for coronal holes for the period 1979-1982 are compared locationwise. Out of 79 CMEs whose locations and spans are known, 48 (61%) CMEs are associated with coronal holes. We make a tentative suggestion that probably the mass ejected during solar flares and active prominences may move along the open magnetic field of the coronal holes and appear as CMEs.

1. INTRODUCTION

The coronal mass ejections (CMEs) have been a focus of intense observational and theoretical researches after their discovery during the Skylab observations. The coronagraphs aboard the SMM and SOLWIND satellites, as well as Mark III polarimeter at Mauna Loa and the Culgoora radioheliograph, have revealed about a complex phenomenon, namely CMEs. The three categories of CMEs are characterized by different maximum speeds (Zirker, 1985). The flare associated CMEs show speed upto 1200 km s^{-1} those associated with prominences upto 600 km s^{-1} and the spontaneous CMEs show speeds only upto about 500 km s^{-1}. Moreover, the prominences CMEs accelerate upto a height of 2-3 R_o, while the flare CMEs achieve their high and constant speed well below this height range (MacQueen and Fisher, 1983). Munro et al (1979) found that 40% of CMEs observed with Skylab were associated with flares, 50% with eruptive prominences (without flares) and 70% with eruptive prominences (with or without flares). Only a few estimates have been made of the mass present in the corona before a CMEs occurs. To within a factor of two, the preexisting mass seems sufficient to account for the mass in the CME (Zirker, 1985). Theoretical models that have attempted to interpret these events are gradually improving but the complete understanding of the dynamics much less the origin of CMEs remains a distant goal (Zirker, 1985). Low (1984) classifies current models of CMEs into two groups one of them represents the CME as a wave like nonlinear MHD response to impulsive energy input at the base of the corona (eg. Dryer et al, 1979; Steinholfson, 1982). The other group represents the CMEs as a magnetically propelled flux loop (eg. Mouschovias and Poland, 1978; Pneuman, 1980, Anzer, 1978; Yeh and Dryer, 1981 a, b). Low (1984) also introduced a third view that the CME is a fully developed MHD outflow. Low suggests that a CME results from the instability of a coronal system, in which magnetic tension and gravity (which tend to stabilize the system) are overcome by the tendency of a magnetized plasma to expand into the surrounding medium. The evolving MHD flow generates features that resemble such observed signatures as voids, loops and blobs.

In the present paper, we report a study of the association between CMEs and coronal holes.

2. OBSERVATIONAL DATA AND ANALYSIS

In our study of the association between the CMEs and the coronal holes, the source of CME data is a paper published by Sheeley et al, (1984) and the source of coronal hole data is a paper published by Stewart et al (1986). These events were selected from the highest quality CME data obtained by the solwind coronagraph experiment aboard the P78-1 satellite during the interval May 1979 to October 1982. During 1979-82, P78-1 satellite recorded 81 CMEs. Out of these, 2 CMEs were excluded from our analysis because location/span of 2 CMEs are unknown. Finally, we were left with only 79 CMEs corresponding to which the coronal hole data is available in the cited paper by Stewart et al.

For elucidating the association between CMEs and coronal holes, we have drawn a circle of radius with span (say, $\pm 5°$, means circle of radius of 5°) of CMEs at location in latitudes (say $S\overline{\ }15$, means 15° in southern hemisphere from equator of the Sun). If the circle drawn above (i.e. equal to radius of CMEs span) contains a coronal hole, we take that the corresponding CMEs and coronal holes are associated. In Table 1 we have shown the yearly association between CMEs and coronal holes. In 1979 a total of 21 CMEs were recorded, out of these 15 are found to be associated with coronal holes. Similarly, in 1980 and 1981 against 17 and 40 recorded CMEs only 7 and 25 CMEs respectively were found to be associated with coronal holes. Again in 1982, the sole recorded CMEs shows association with a coronal hole. In all, during 1979-82 out of 79 recorded CMEs, only 48(61%) were found to be associated with coronal holes.

TABLE: 1: Association between coronal mass ejections (CMEs) and coronal holes

Year	Number of CMEs	Number of CMEs associated with coronal holes
1979	21	15
1980	17	07
1981	40	25
1982	01	01
Total	79	48 (61%)

In Fig 1 the circle (equal to CMEs span radius) as plotted and found that these 2 CMEs are not associated with coronal holes. Whereas in Fig 2 we have drawn circles for 1,4,6,15 and 17 Nov. 1979 CMEs events and found that all the five CMEs span circles are associated with coronal holes. Earlier described technique is used for studying the association between CMEs events and coronal holes.

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Fig. 1

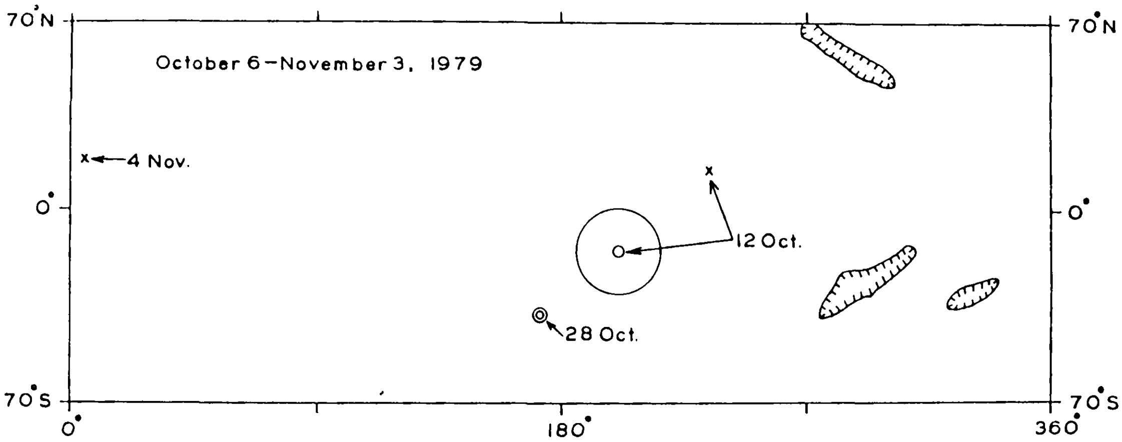
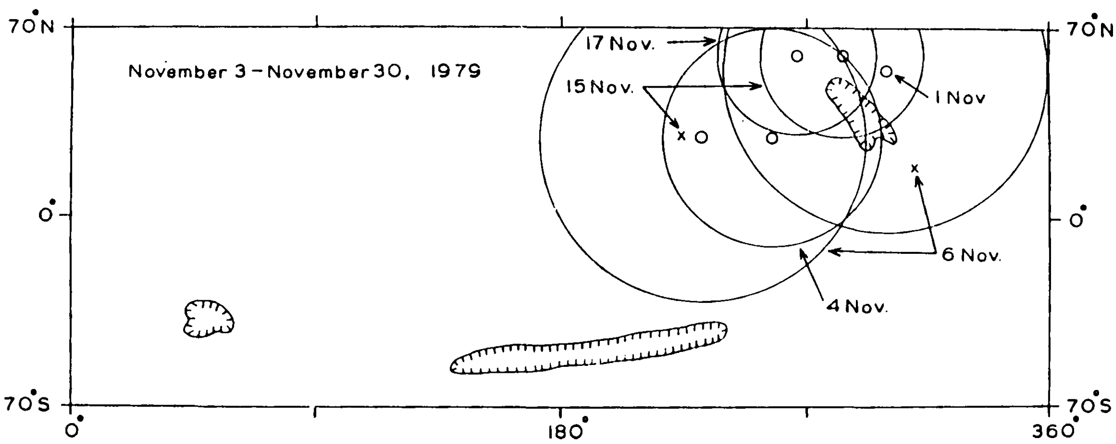


Fig. 2



Figs. 1 and 2. Plot of circle of radius equal to CMEs span at location of CMEs and positions of coronal holes observed in one solar rotations period. The cross (X) mark and small circle (O) mark show locations associated flares and centre locations of CMEs.

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3. RESULTS AND DISCUSSION

The results of the present study show that out of 79 CMEs whose locations and span are known, 48 (61%) CME circle contain coronal holes. From details like those given in Fig 1 we infer that mostly sharp (small span 20°) CMEs are not associated with coronal holes. Further, the sharp (small span) CMEs may be produced by various models, proposed by various investigators, described in a recent review by Zirker (1985). On the other hand we suggest that the CMEs associated with coronal holes may be produced by some mechanism by which the mass ejected by some flares or active prominences, gets connected with open magnetic field lines or coronal holes and moves along these open magnetic lines of coronal holes to produce large span CMEs.

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