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Initial Overview of Disconnection Events in Halley's Comet 1986

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Abstract

We present an initial overview of the disconnection events (DEs) in Comet Halley in 1986. Although disconnection events are arguably the most spectacular of all dynamic comet phenomena, the mechanisms by which they occur are not fully understood. It is generally believed that the solar wind plays a major role in determining when disconnection events occur, but the details of the solar wind/cometary interactions responsible for initiating the tail disconnection are still under debate. The three most widely accepted models are (1) high speed streams in the solar wind cause the tail to disconnect due to pressure effects, (2) decreased production of cometary ions in a high speed stream allows magnetic field to slip away from the comet, and (3) the tail disconnects after frontside reconnection of the interplanetary magnetic field (IMF) as the comet crosses a magnetic field sector boundary. See the paper by Brandt (1990) for additional discussion and references.

We find that the front-side magnetic reconnection model is the best explanation for the DEs we have considered.

1 WHAT'S A DE?

The most spectacular of all plasma tail phenomena is the disconnection event or DE, in which the plasma tail is severed from the cometary head. Normally, the plasma tail is attached to the head region by the magnetic field lines embedded in the cometary ionosphere. Several individual DEs have been analyzed in comet Halley in order to understand the physical mechanisms involved when the tail and head are detached. An example of the analysis of an individual DE (16.0 March 1986) is given in the paper by Randall *et al.* (this volume). The number of analyzed DEs is now sufficient to begin considering them in groups.

2 POSSIBLE DE MECHANISMS

2.1 Pressure Effects

Higher than average values of solar wind speed or density (or both) could greatly compress the cometary ionosphere and allow the magnetic field lines (and hence the plasma tail) to slip around the head. In extreme cases, high pressure could simply blow the ionosphere and the tail away from the head region.

Figure 1: Comet Halley on 12 April 1986. DE began 10.9 April. (F. Miller, University of Michigan/CTIO)

2.2 Ionization Effects

Suppression or cessation of ionization could alter the ionosphere and allow the field lines to slip away from the comet.

2.3 Magnetic Reconnection

Pressing magnetic field lines of opposite polarity into the cometary ionosphere (at sector boundaries or other instances of reversal of the Interplanetary Magnetic Field (IMF)) could sever the attachment by magnetic reconnection.

3 TESTING OF MECHANISMS

3.1 Solar Wind Density and Speed

These are determined from *in situ* measurements and are referenced to the comet by standard co-rotation methods. See the summary of solar wind conditions in table 1.

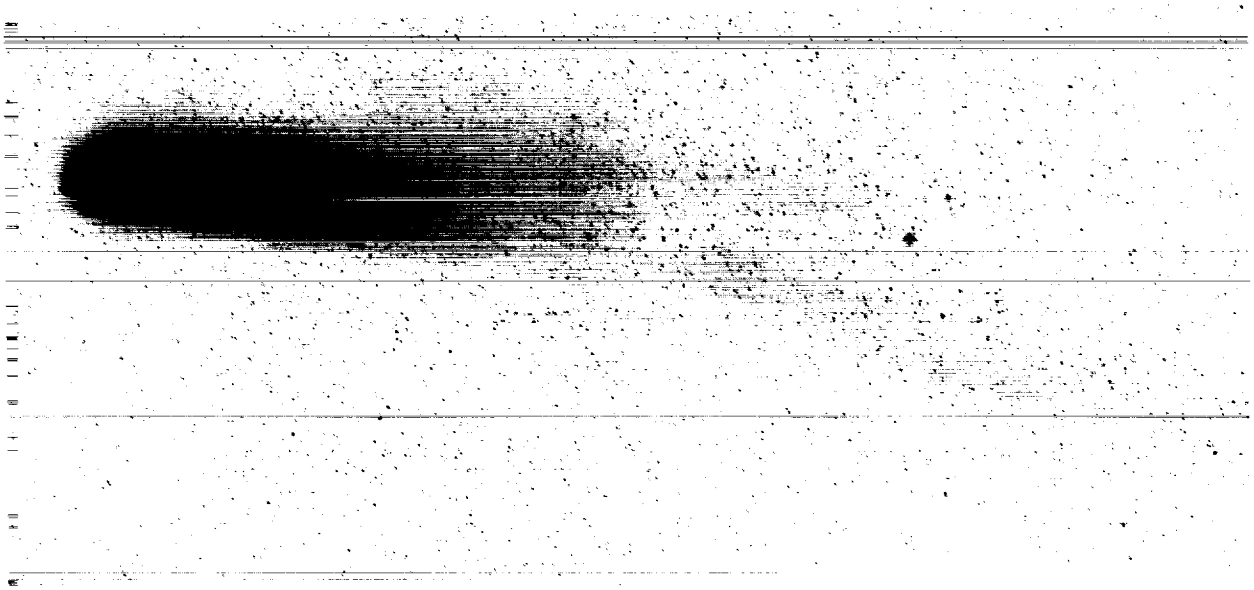

Figure 2: Comet Halley on 18 March 1986. DE began 16.0 March. (G. Pizarro, European Southern Observatory)

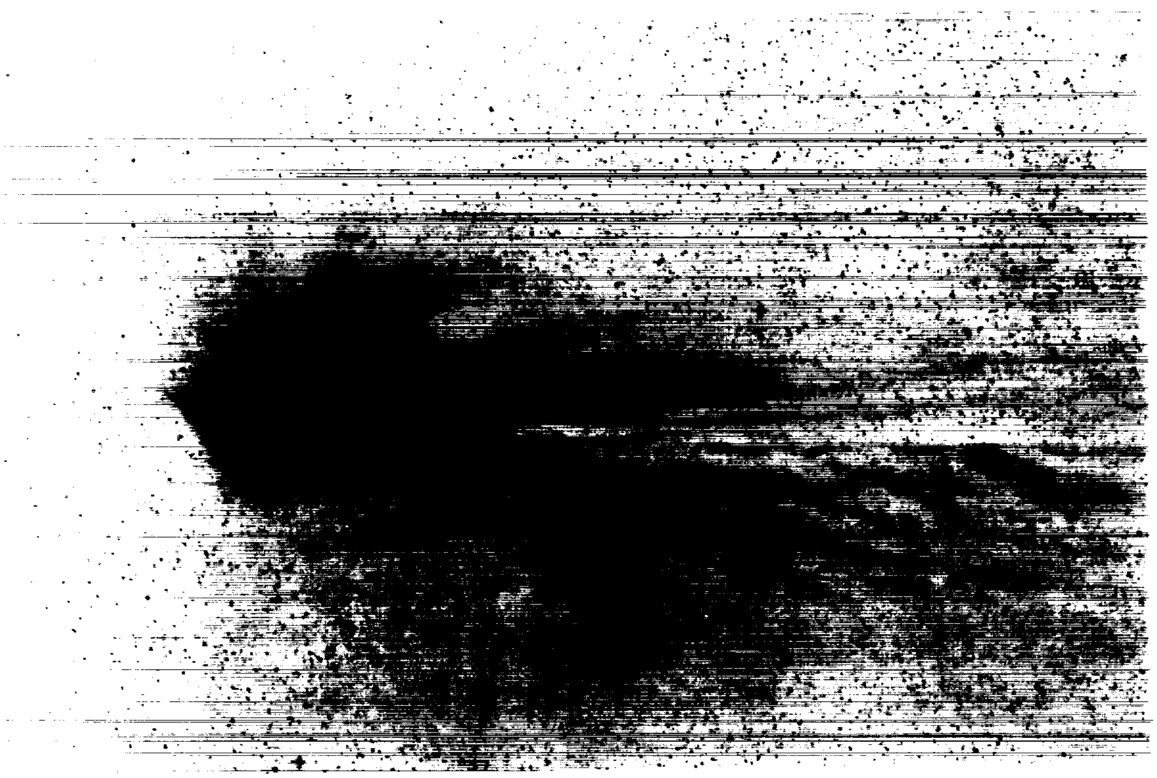

Figure 3: Comet Halley on 22 February 1986. DE began on 21 February. (UK Schmidt Telescope)

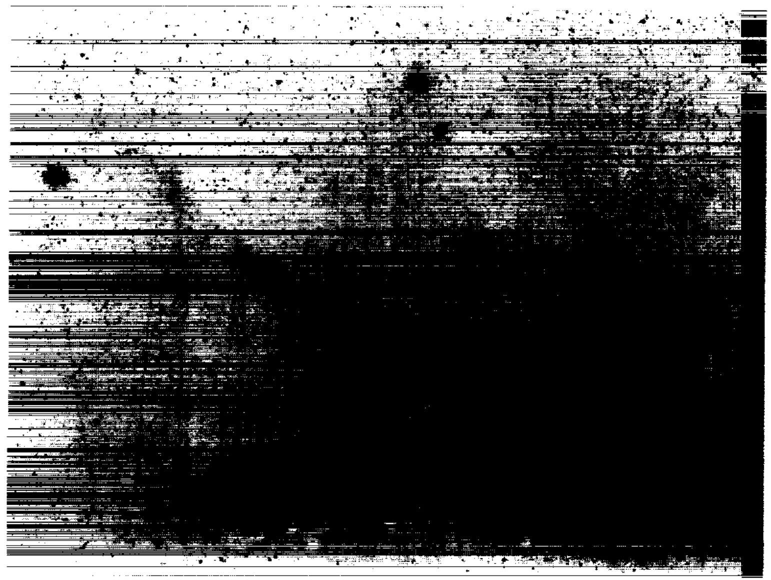

Figure 4: Comet Halley on 11 January 1986. DE began 9.7 January. (E. Moore/E. Marr, Joint Observatory for Cometary Research)

3.2 Sector Boundaries

These occur when the earth, comet, or spacecraft crosses the heliospheric current sheet. As a test of the front-side magnetic reconnection mechanism (Niedner and Brandt 1978), we can consider a specific area of the calculated heliospheric current sheet, which is projected into interplanetary space from potential models giving the magnetic field at approximately 2 $R_{\odot}$. The projected positions of the heliospheric current sheet can be checked against the direct measurements from spacecraft such as IMP-8, ICE, and PVO. We find that while the heliospheric current sheet for January through April 1986 had a complex shape which changed with the solar rotation; the gross qualitative features remained relatively constant during this period. See figure 5 which shows the preliminary position of the current sheet. In particular, the highlighted area of figure 5 shows a portion of the heliospheric current sheet that is stable and highly inclined to the solar equator; these circumstances are favorable for comparisons with cometary data.

4 PRELIMINARY SECTOR BOUNDARY CROSSINGS OVERVIEW

The values given in Table 1 are derived from IMP-8 measurements at the earth which are corotated to the comet's location. The r^{-2} variation with heliocentric distance is also taken into account in our estimation of the density, N_e.

Summary of Solar Wind Conditions

DE	Density N_e (cm^{-3})	Speed w (km/sec)	Magnetic Reversal
9 Jan 1986	$\sim 7-25$	~ 400	YES
21 Feb 1986	~ 25	~ 700	YES
16 Mar 1986	~ 8	~ 600	YES
10 Apr 1986	~ 10	~ 350	YES

Table 1: These conditions should be compared with the average conditions *at earth* of $N_e = 8$ cm^{-3} and $w = 400$ km/sec.

Figure 5 shows the calculated current sheet for Carrington rotations 1770 through 1773, spanning the time period from mid-December 1985 to mid-April 1986 (Hoeksema 1989). The solid circles denote the positions at which various spacecraft, (IMP-8, ICE, and PVO) measured magnetic field reversals. The generally good correspondence between these measurements and the calculated sector boundary supports the validity of the calculations for these latitudes. The asterisks denote the position of Comet Halley with respect to the current sheet at the beginning of the disconnection events on 10 April, 16 March, 21 February and 9 January (left to right). The salient point is that each of these events occurred immediately after the comet crossed the same part of the magnetic field sector boundary during each solar rota-

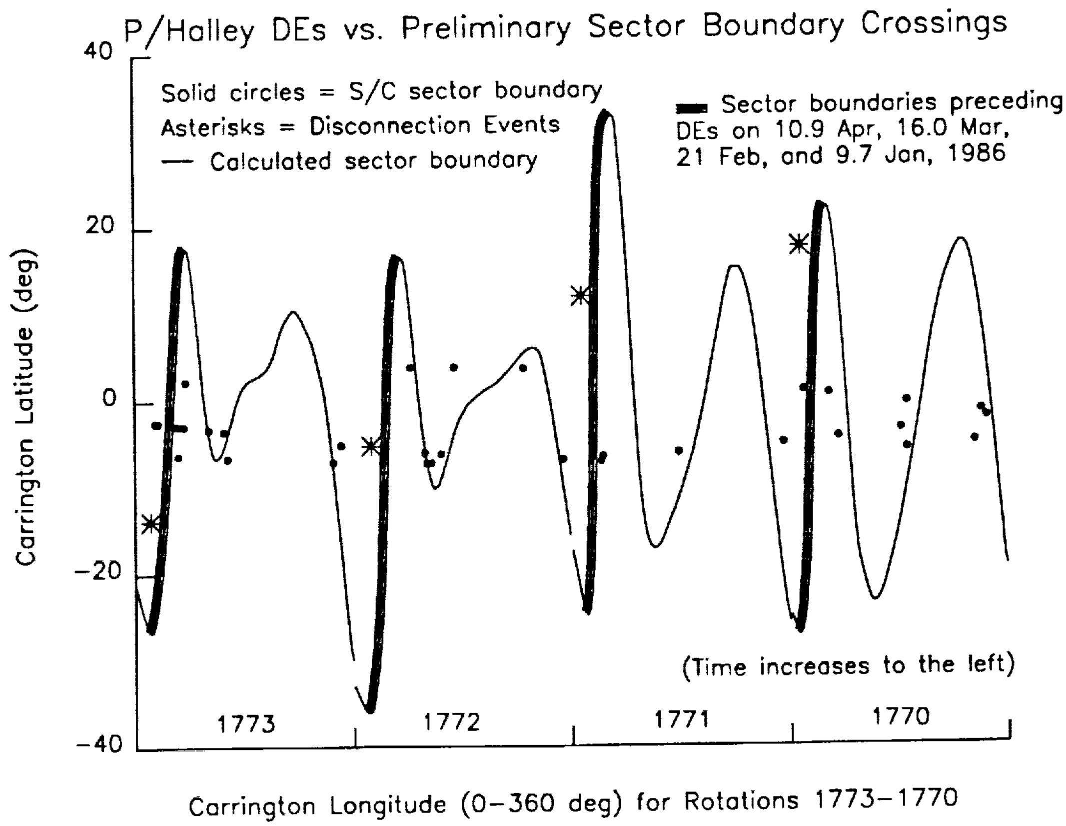

Figure 5: Carrington rotations 1770 through 1773 spanning the time period from mid-December 1985 to mid-April 1986.

tion (highlighted region of the calculated current sheet).

5 Conclusions

We find that the same area of the heliospheric current sheet, or sector boundary, encountered comet Halley on about 9 January, 21 February, 15 March and 10 April. On all four of these crossings, we find the corresponding DEs. At the times of these DEs, the solar wind speeds were average to somewhat elevated and the solar wind densities were normal with the exception of the 21 February DE and possibly the 9 January DE. Therefore, we conclude that the occurrence of DEs caused by front-side magnetic reconnection is the best possibility for the events studied here.

Further work is still necessary in order to refine the calculation of the sector boundary. This will include, for instance, consideration of various source surface radii in the potential field model, and the use of spacecraft measurements to determine fine structure. Work is also in progress to perform similar analyses of other DEs in Comet Halley. We note the recent paper by Delva *et al.* (1991) on this subject.

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