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The Disconnection Event of 16.0 March 1986 in Comet Halley

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Abstract

From kinematic extrapolation of tail/nucleus distance measurements on photographic images in the International Halley Watch (IHW) archive, we calculated the disconnection time of the 16-19 March 1986 event to be 16.0 (±0.1) March. The solar wind conditions around Comet Halley at the time of the DE, inferred by corotation of IMP-8 satellite data to the comet, were such that (1) Comet Halley had just crossed the interplanetary magnetic field (IMF) sector boundary; (2) the solar wind density was ~ 8 cm^{-3}; (3) the solar wind speed was ~ 600 km/sec, (4) the IMF magnitude was ~ 8 nT. Given these conditions, we conclude that the most likely cause of the 16.0 March DE was front-side magnetic reconnection, as described in the model of Niedner and Brandt (1978).

PHOTOGRAPHIC EVIDENCE

We have analyzed photographs from the International Halley Watch (IHW) archive throughout the 1985-1986 Comet Halley appearance. Figure 1 is a sequence of photos taken between 16 March 1986 and 19 March 1986.

They clearly show the occurrence of the disconnection event, and the evolution of the large scale structure of the comet tail on a daily basis after the DE. From the images we have determined the precise time of the DE, and have examined the solar wind conditions and interplanetary magnetic field at this time in order to ascertain whether any correlations were evident which would support one of the proposed mechanisms for DE occurrence.

RESULTS

From kinematic extrapolation of tail–nucleus distance measurements on the photographs, (see figure 2) we calculated the disconnection time of the 16-19 March 1986 event to be 16.0 (±0.1) March. In calculating these distances, we assumed that the tail receded along the prolonged radius vector — a reasonable assumption during the first few days after the DE. The solid line through the data points is the best-fit second order polynomial assuming a constant acceleration of the disconnected tail from the nucleus. Because of this assumption, we fit the polynomial to only the earliest data points (up to a distance fo 5 million kilometers), during which time the acceleration appears constant. The extrapolated disconnection time of the DE is approximately 16.0 March with an uncertainty of about 0.1 days. The downstream acceleration of the disconnected plasma tail is about 15.6 cm/sec^2, and the velocity at the time of disconnection is about 8.2 km/sec.

SPACECRAFT DATA

We inferred solar wind conditions around Comet Halley by corotating data from the IMP-8 satellite to the comet. Using this dataset, we determined that at the time of the DE the solar wind speed at the comet was ~ 600 km/sec; the solar wind density was ~ 8 cm^{-3}; and the IMF magnitude was ~ 8 nT. These conditions are not particularly unusual, and thus would *not* be expected to have caused the observed DE via mechanisms such as ion production or pressure effects.

The relative trajectories of the Pioneer Venus Orbiter (PVO), IMP-8, the International Cometary Explorer (ICE), Vega-1, and comet Halley were calculated assuming an Archimedian spiral for the solar wind propagation, and are plotted in fig. 3 along with the calculated neutral line. The dots on the spacecraft (and comet) trajectories denote positions of the spacecraft (comet) on the dates designated in the figure. The open diamond-shaped marks on the trajectories of the spacecraft represent sector boundary detections by the corresponding spacecraft. The open triangles on the comet Halley trajectory represent times of observations of comet plasma tail DEs.

The two spacecraft observations (IMP-8 and Vega-1) available near the appropriate portion of the neutral line constrain the sector boundary very well. We have no PVO data for the end of February 1986 to further define the shape of the current sheet for this Carrington Rotation. From analysis of other DE's, we have found that a delay of ≈ 0.7 days between the comet crossing the sector boundary and the DE is typical (due to the merging and reconnection of the field lines on the front side of the comet which produces the disconnection of the tail).

DISCUSSION

We estimated the position of the IMF neutral sheet using two different methods: 1) the times and positions of 180-degree phase shifts in the IMF

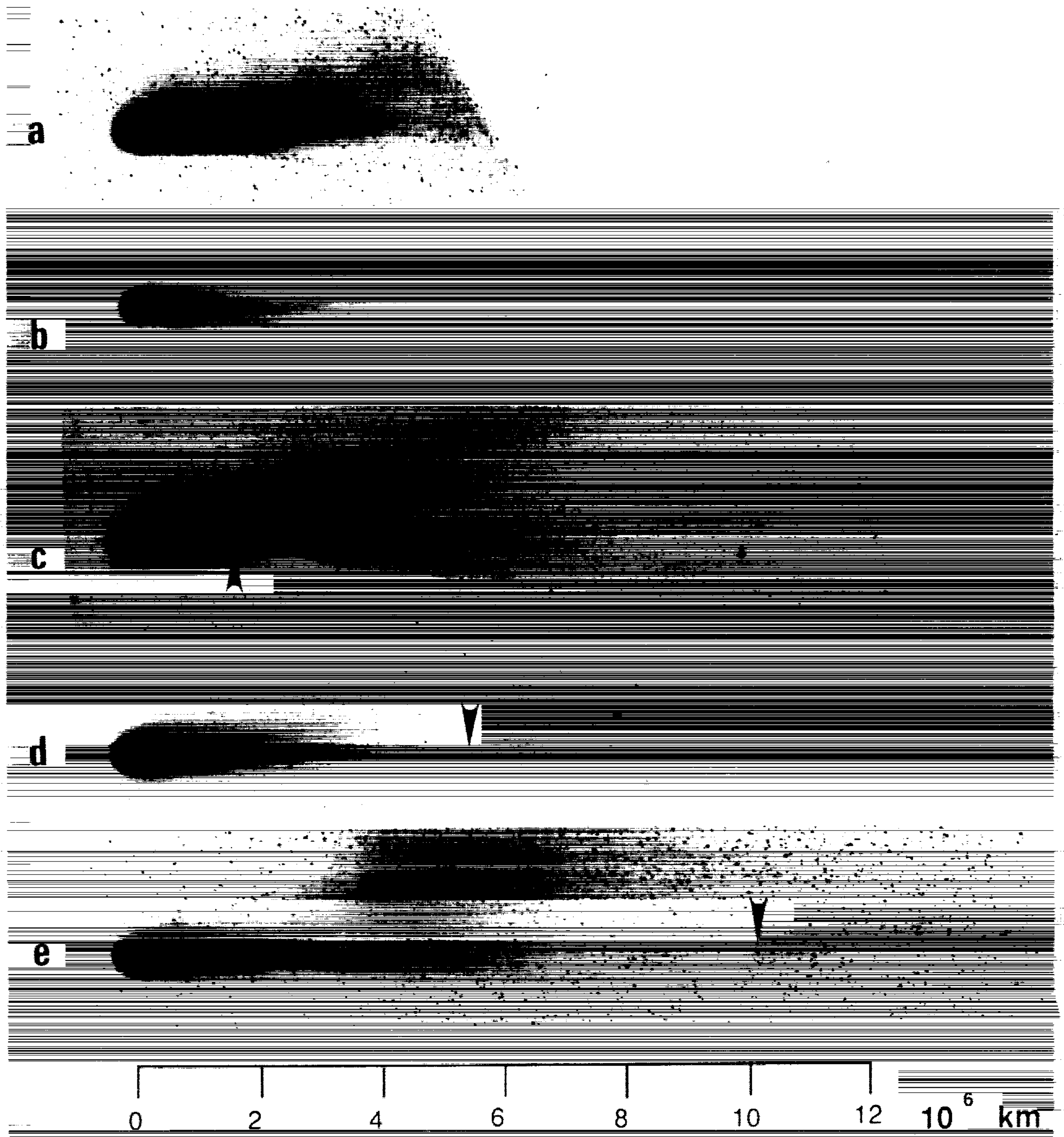

Figure 1: Time sequence of photographs of comet Halley depicting the disconnection event of 16.0 March 1986. The dates of these images are (a) 15.97 March (K. Sivaraman, Indian Inst. for Astrophysics, Kavalur Sta.), (b) 16.36 March (F. Miller, University of Michigan/CTIO), (c) 17.37 March (G. Pizarro, European Southern Observatory), (d) 18.34 March (C. Torres/H. Wroblweski, Cerro el Roble Obs.), and (e) 19.47 March (W. Liller, LSPN Island Network).

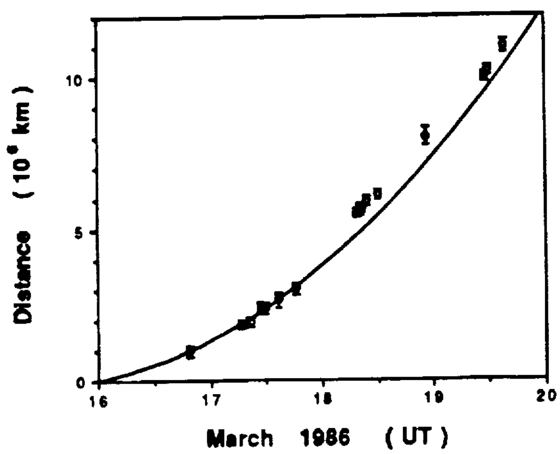

Figure 2: Distance of disconnected tail from nucleus.

direction were measured by the IMP-8, ICE, and PVO satellites, and then corotated to comet Halley's orbit, and 2) the neutral sheet calculated at the solar source surface was corotated out to the comet. Both methods are consistent with one another, and show that comet Halley crossed a magnetic field sector boundary shortly before the 16 March DE. The observations from IMP-8 of the particle density N_e and solar wind velocity w indicate that neither was particularly high at the time of this DE. We therefore conclude that the most likely cause of this disconnection event was front-side reconnection of the magnetic field.

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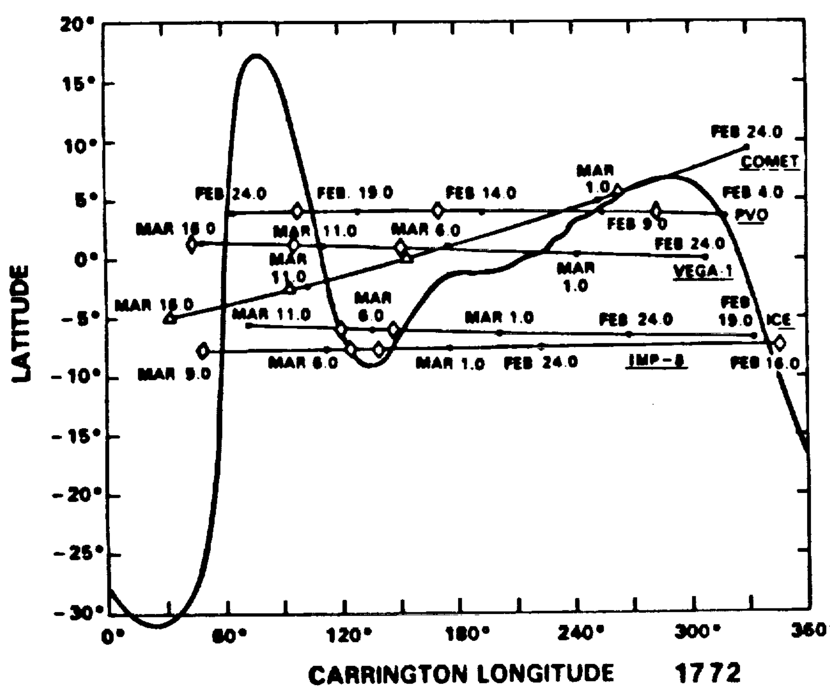

Figure 3: Carrington map of the computed coronal magnetic neutral line for Carrington rotation 1772. (Figure adapted from Niedner and Schwingenschuh (1987)).