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INTERPLANETARY MAGNETIC FIELD CHANGES AND CONDENSATIONS IN COMET HALLEY'S PLASMA TAIL

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ABSTRACT

In a time-dependent three dimensional MHD simulation for cometary plasmas, Schmidt-Voigt (1989) could observe the formation of condensations in the plasma tail after a 90 degree change in the interplanetary magnetic field (IMF) sweeping over the comet. We investigated the IMF measurements of the Vega SC in the vicinity of the comet Halley for 90 degree changes in the clock angle and studied the relation between them and optical observations of condensations in the plasma tail. For the time interval 24 Feb. 86 to 14 Mar. 86, we could not find a correlation between such changes and the release of condensations from the cometary head.

INTRODUCTION

In a paper by Schmidt-Voigt (1989), a time-dependent three dimensional MHD simulation of cometary plasmas was presented. It studied how features in the plasma tail of a comet change if conditions in the onstreaming solar wind are modified. Especially, 90 degree changes in the direction of the interplanetary magnetic field (IMF) were investigated. The author found the following effects on the modelled plasma tail: at the time where the magnetic discontinuity sweeps over the cometary head, the plasma density is locally enhanced due to the additional effect of the magnetic stresses $(\mathbf{B}.\nabla)\ \mathbf{B}/(4\pi)$ from the original and modified magnetic field. Because of the draping of the original field in front of and the new IMF behind the discontinuity, the magnetic stresses of both fields act together and compress the plasma in front of the comet from two sides. A condensation is formed and subsequently transported down the tail (see Schmidt-Voigt (1989), fig. 11). Since the total pressure is cylindrically symmetric with respect to the tail axis and the total pressure gradient radially away from it is small, the condensation does not expand radially. Only the (also small) pressure gradient along the tail axis will allow a slow spreading of the plasma along it, while the condensation is moving down the tail. The condensation can be seen as enhancement of the column density, for several hours its brightness is even higher than that of the coma (see Schmidt-Voigt (1989), fig. 12) and therefore possible to be observed optically.

The Soviet SC Vega-1 and Vega-2 passed near Halley's comet on 6.3042 March 1986 in 8890 km, resp. 9.3042 March in 8030 km distance and almost continuously measurements of the interplanetary magnetic field have been recorded by the magnetometer experiment on board. The relative positions of the SC and the comet around closest approach are shown in Delva et al. (1991), fig. 1.

On the other hand, a big effort was made by the IHW to make different types of ground-based observations of the development of the comet. Especially many plates of the plasma tail were taken; they show several features like condensations moving down the tail, disruptions (so called disconnection events) of the whole tail, etc.
We therefore here investigated the available IMF data, measured directly in the neighbourhood of Halley's Comet, for 90 degree changes in the direction and looked if there is any correspondance between them and the plasma tail condensations observed.

ANALYSIS OF THE DATA

Magnetometer Data

Due to the compression of the onstreaming IMF in front of the comet, the angles of the **B** - vectors with the line Sun - Comet are aligned to 90 degree angles, so the cone angle plays no longer a role and the clock angle (clock angle=arctan(Bz/By) for Bx in direction to the Sun, Bz to ecliptic north) is the main parameter of the field when sweeping over the comet. In the time series of our IMF data, we searched for 90 degree changes in the clock angle for an interval of about 20 days around the closest approach of the Vega-1 SC (24 Feb. to 14 Mar. 1986). First, the data where averaged over intervals with only small changes, to accentuate the global behaviour of the clock angle. Changes between 75 and 105 degrees were picked out (to allow slight deviations from the sharp 90 degree limit). The time of occurrence of the change at the SC was corotated to the position of the comet by means of formula (1) of Delva et al. (1991), using the actual solar wind velocity as measured on the SC by the PLASMAG-instrument (M. Tatrallyay (1991)). For calculation of the corotation time, differences in ecliptic latitude were neglected: it was only looked when the same arc of Archimedean spiral that passed over the SC swept over the comet. For this time interval, the difference in ecliptic longitude between SC and comet is small and corotation times are short, up to about 36 hours at most.
The 90 degree changes in the clock angle are shown in Fig. 1, at the time they are expected to reach the comet, and in terms of numbers of events per day, with a total of 26 events. The changes on March 6 are shown only dashed, since the field there is influenced by the comet and due to the draping some events can be measured several times.

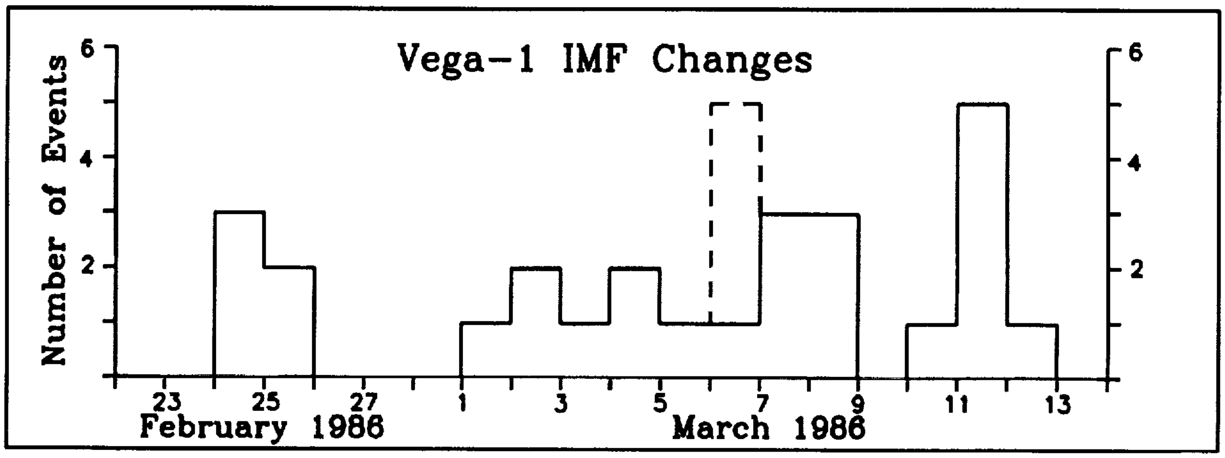
Observations of Comet Halley's Plasma Tail

A detailed list of plasma tail observations of Comet Halley was published by Celnik and Schmidt-Kaler (1987). These authors observed the plasma tail for a period of more than two months and identified series of condensations moving down the tail. From their time-distance data, they determined the time of release of the condensation from the cometary head (Celnik et al. (1988)). We took the data of emissions of condensations from their Table 4. They are here shown in Fig. 2 in terms of number of emissions per day, with a total of 31 events.

Representation of the Data

The IMF data show sometimes several subsequent changes as well as some more "quiet" times (Fig. 1). The same is the case for the release of condensations from the cometary head. Due to the slight inaccuracy introduced through the necessary corotation of the IMF features, a comparison of a single IMF clock angle change with a single condensation seems to be a risky task. For sake of correctness, we prefer to correlate only the general behaviour of both parameters: if more 90 degree changes occur over a short time (e.g. per day), we should expect more releases of condensations at that time. Therefore, we present the two datasets as histograms of events per day.

Fig. 1: Histogram of 90 degree changes in the clock angle of the IMF, measured by Vega-1 and corotated to comet Halley, in nr. of changes per day; total number of events: 26 (or 30 including the dashed ones).



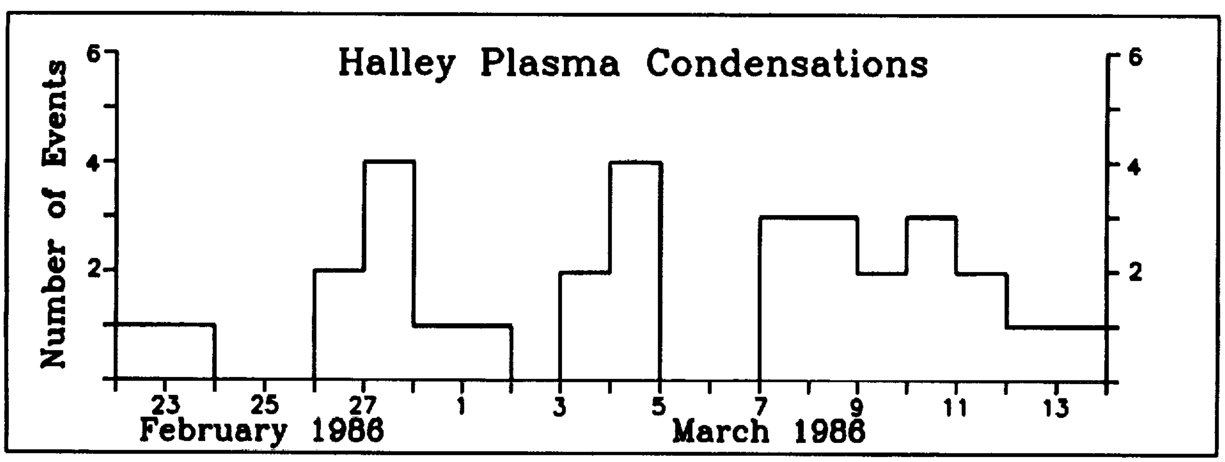


Fig. 2: Histogram of release of plasma clouds from the cometary head (after Celnik and Schmidt-Kaler (1987), Table 4) in nr. of releases per day; total number of events: 31.

RESULTS AND DISCUSSION

If a correlation as suggested by Schmidt-Voigt exists, then Fig. 1 and 2 should have similar shapes: a high number of 90 degree changes should coincide with a high number of releases of condensations. However, from Fig. 1 and 2 we can see no such correlation: sometimes many condensations are released without any 90 degree clock angle change (e.g. 27 Feb.). Sometimes the situation is vice versa (e.g. 11 Mar.) and on other days both types of events occur.

From the PLASMAG-experiment on the Vega SC of the same period, measurements of the solar wind velocity show a high spread stream with a sharp velocity enhancement up to 700 km s^{-1} to arrive at the Comet on 28 Feb., a slow decline to 400 km s^{-1} until 6 - 7 Mar. and again a steep enhancement to 600 km s^{-1} on 8 - 9 Mar. with decline until 12 Mar. (M. Tatrallyay (1991)). In Fig. 2, a higher number of releases can be seen on days of high solar wind velocity sweeping over the comet. This may indicate that the variation of the solar wind velocity plays a role in the development of plasma condensations.

From the present investigation we conclude that the effect seen in the numerical MHD simulation is not seen in the observations of the IMF and the plasma tail of Halley's Comet. An MHD simulation with variation of several parameters would be desirable for better understanding of the influence of the single parameters on the structures in the plasma tail.

References

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