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THE DISTURBANCE OF THE PLASMA TAIL OF HALLEY'S COMET ON MARCH 12–14, 1986

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Abstract

The plasma tail of comet Halley showed outstanding disturbances in March, 1986. The disturbances were well observed from the ground, owing to the good geometrical condition. The comet Halley spacecraft "SAKIGAKE" provided us with direct observational data on the solar wind during 10–11 of this month, regarding a possible effect on the tail disturbances during the later days. Hence, a remarkable disturbance of the plasma tail of comet Halley observed during 12–14, March is analyzed in the present paper based on eight photographs taken from the ground. The distance X from the nucleus to the kinked type disturbance and the velocity V of the kink are measured for time t, and are expressed by X–t and V–t curves, respectively. The curves coincide quite well with those of the January 10–11 kink event and are not coincident with those of the December 31 DE event of comet Halley. Hence, our March 12–14 disturbance is concluded not to be a DE by the dayside crossing process, but to be a kink generated in the ordinary flow by the similar process with the January 10–11 kink event.

1. Introduction

Numerous activities and disturbances of the plasma tail were observed during the latest apparition of comet Halley. Among these, several disturbances were analyzed as tabulated in the following list:

Dates	Events	Authors	References
31/12/85	knot	Saito et al.	AA 209
10–11/ 1/86	kink	Tomita et al.	AA 215
7–10/ 3/86	DE	Niedner, Schwingenschuh	AA 103
8–10/ 3/86	DE	Wu, Qiu	AA 264
20–22/ 3/86		Brosius et al.	AA 267
11–12/ 4/86	DE	Brosius et al.	AA 267
11–12/ 4/86	DE	Lundstedt, Magnusson	ESLAB 141
14–15/ 4/86	DE	Lundstedt, Magnusson	ESLAB 141

("AA" and "ESLAB" represent "Astron. Astrophys. 187, 1987 ··· special issue of Halley's Comet" and "20th ESLAB Symposium on the Exploration of Halley's Comet, Vol. 1", respectively.)

In addition to these, an outstanding tail disturbance event occurred on 12–14, March 1986. In the present paper, a disturbance event during this period will be analyzed and discussed for the following two reasons: The solar wind, whose physical parameters were measured by many spacecraft, was to interact with comet Halley during this period after a mass loading delay. And the tail disturbances during this period have not been analyzed yet, even though the disturbances were active owing to good observational geometrical conditions.

2. Ground-based Photographs

Since the declination δ in the equatorial coordinates of the comet was $-21^\circ \sim -23^\circ$ during this period, many photographs were taken mainly by observers in the southern hemisphere. Professional astronomers in the hemisphere took very fine photographs by using large telescopes. However, the change of the plasma tail was so rapid that all phases of the disturbances could not be covered by the limited professional observers and/or observatories. Hence, ground-based photographs taken by both professional and non-professional astronomers will be analyzed in the present work. The eight photographs showing a characteristic kink type condensation in the tail are displayed in Figure 1 together with their data in Table 1.

Table 1

No.	Time (UT)	Observer
a	1986 3 12.180	O. Matsuura
b	3 12.837	N. Kimura
c	3 13.776	N. Nishitani
d	3 13.831	N. Kimura
e	3 13.839	N. Kimura
f	3 13.847	N. Kimura
g	3 13.855	N. Kimura
h	3 14.826	H. Tomioka

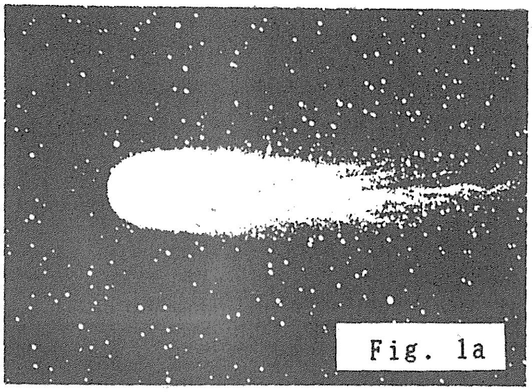

Fig. 1a

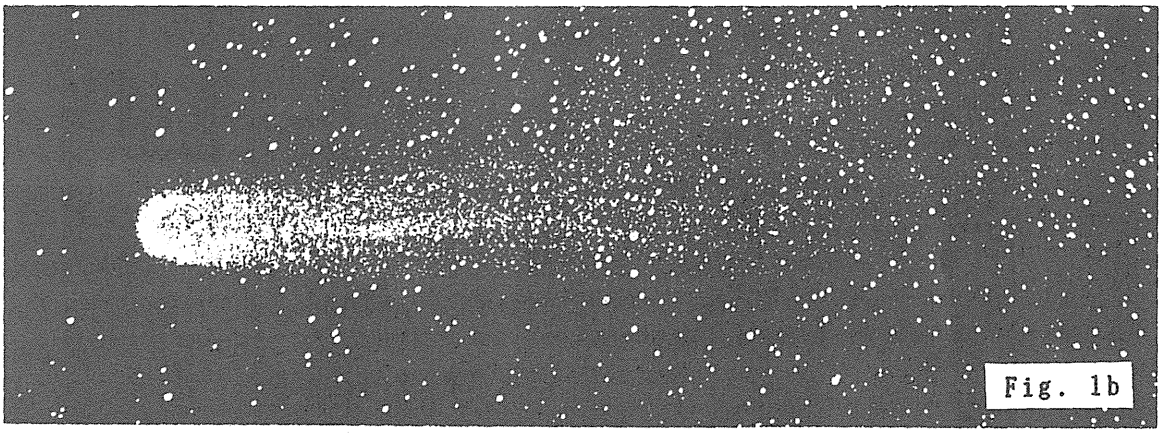

Fig. 1b

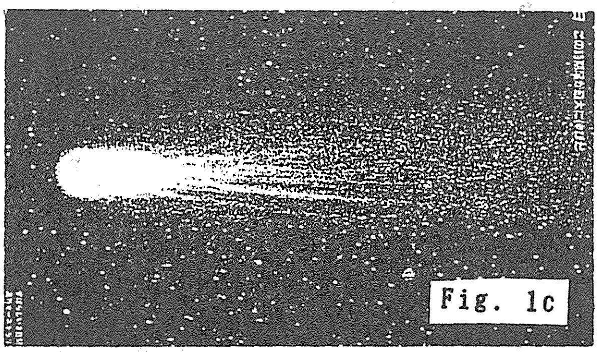

Fig. 1c

Fig. 1d

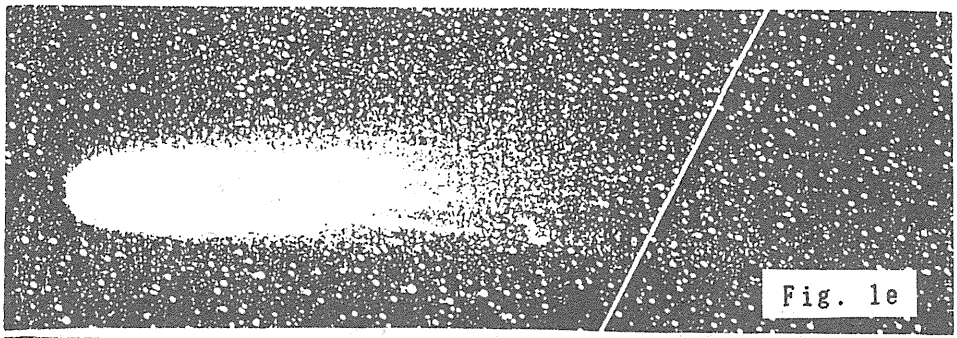

Fig. 1e

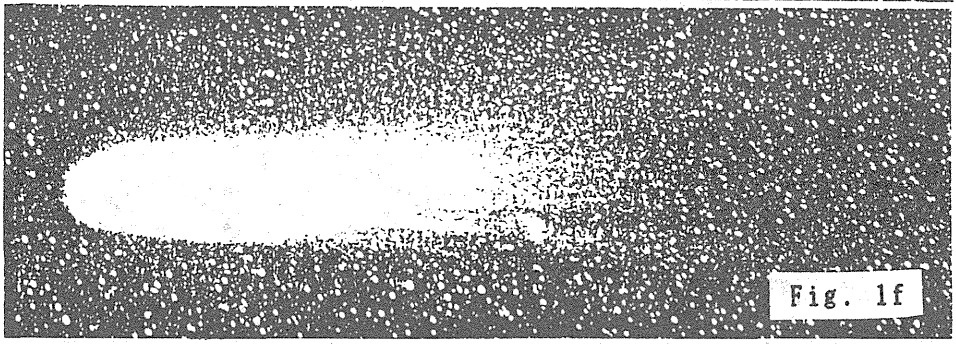

Fig. 1f

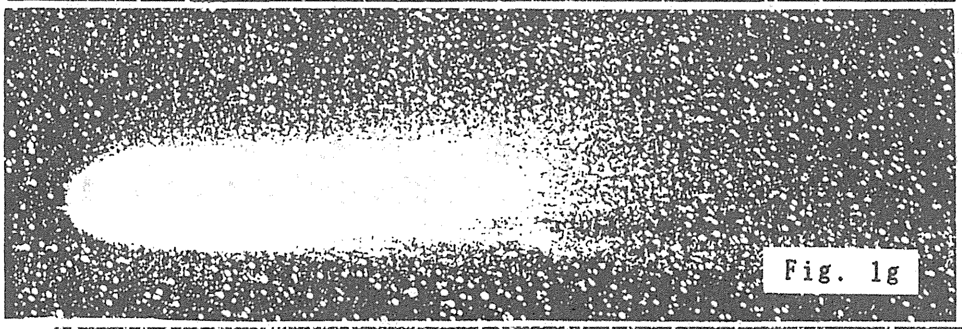

Fig. 1g

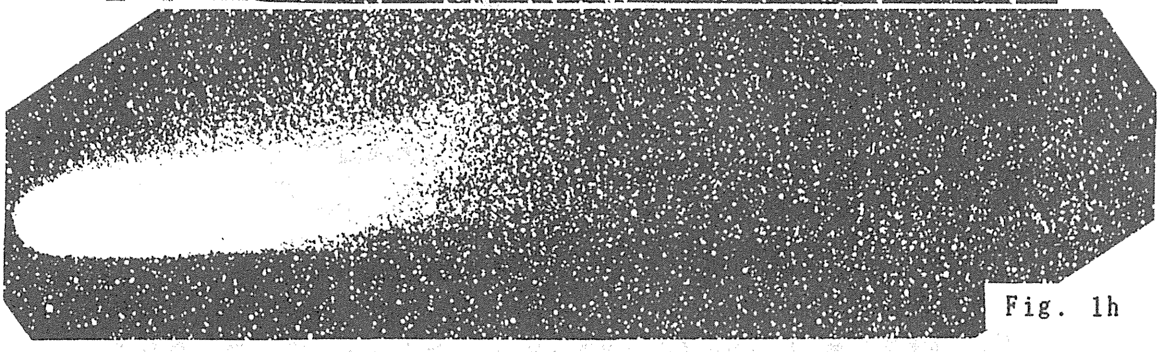

Fig. 1h

3. X–t and V–t Relation of the Disturbance

On each photograph we can identify the position of the kink by measuring its celestial coordinates referring to fixed stars. We transcribed the features of the plasma tail with the kink on the SAO Star Chart as illustrated in Figure 2. Comparing the kink with the calculated position of the cometary nucleus, we obtain the angular distance from the nucleus to the kink for each photograph.

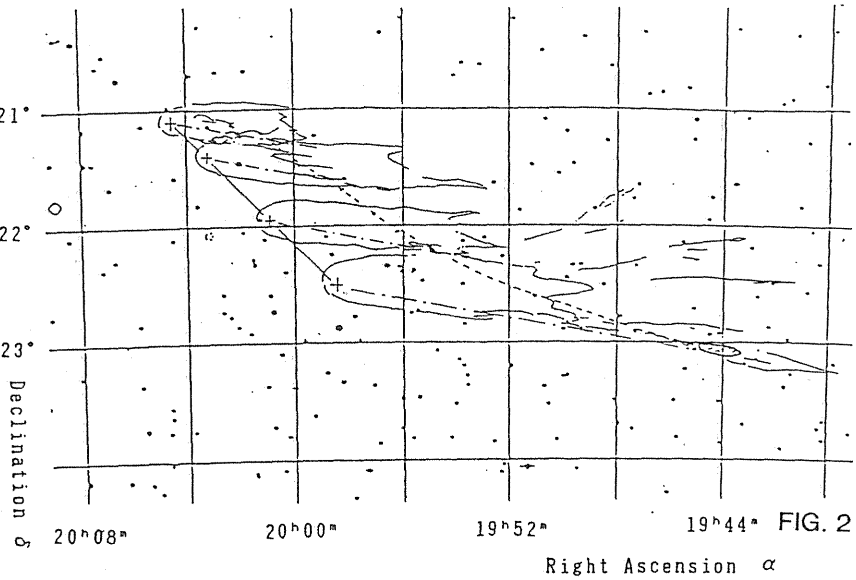

FIG. 2

Figure 3 shows the motion of the comet's nucleus and the kink for the time t. The spatial distance X in km from the nucleus to the kink is calculated assuming that the plasma tail extended towards the anti-solar direction. The X–t curve is shown in Figure 4. Taking the time difference of X, we obtain the spatial velocity V of the kink for time t as shown in Figure 5.

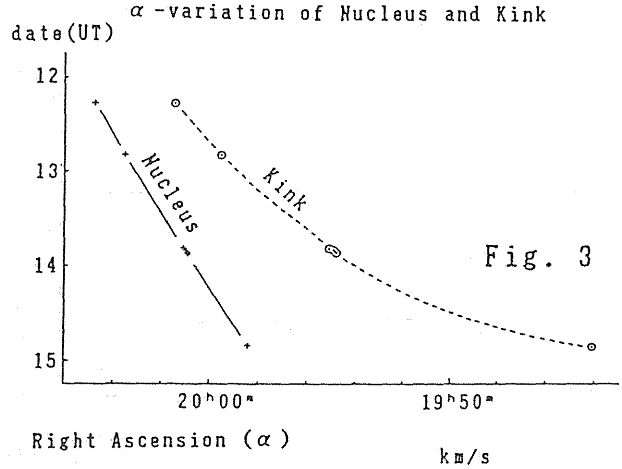

Fig. 3

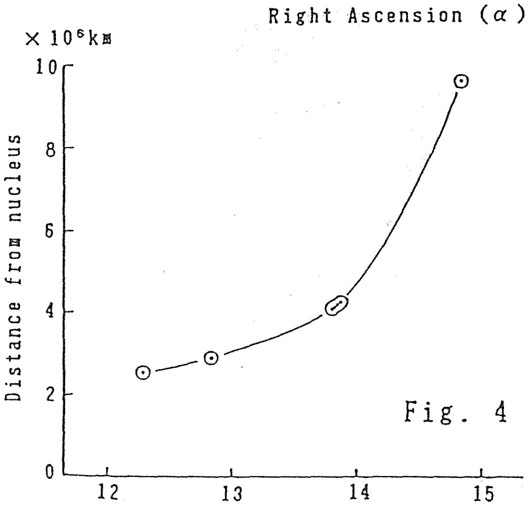

Fig. 4

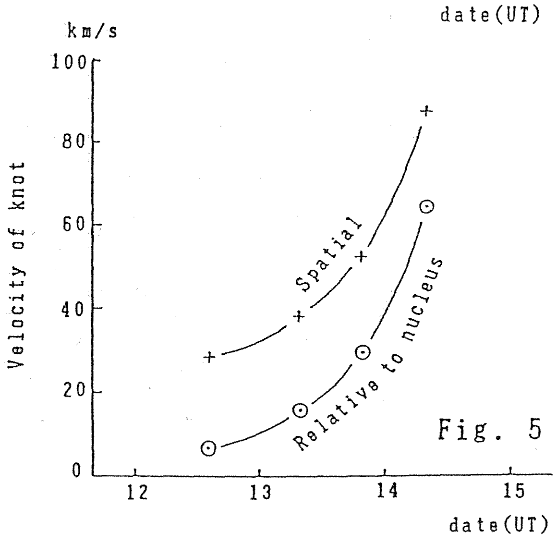

Fig. 5

4. Interpretation for the Flow of the Kink

Prior to the period of this analysis, the five spacecraft encountered the comet and measured directly the physical quantities of the space around the comet. For example, the

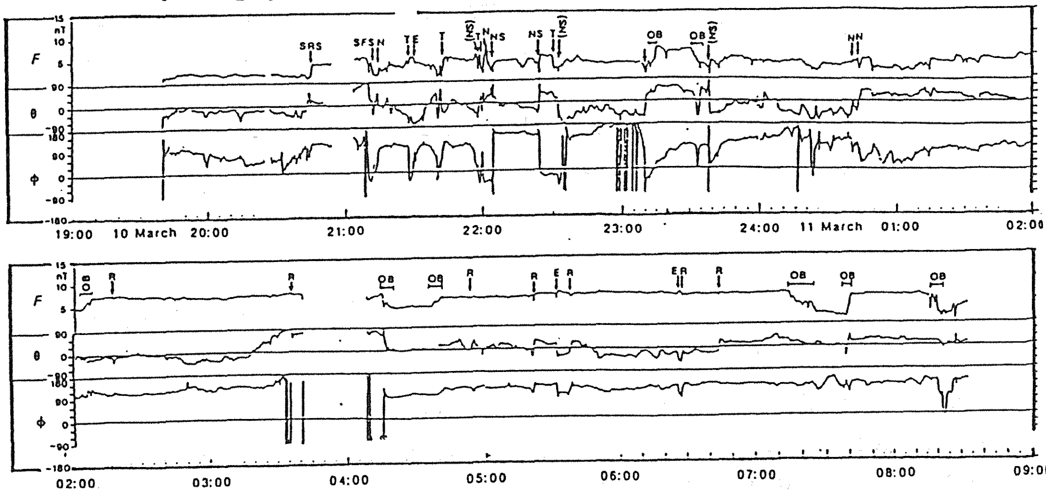

Fig. 6 The magnetic field observed by "SAKIFGAKE" (after Saito et al., 1986)

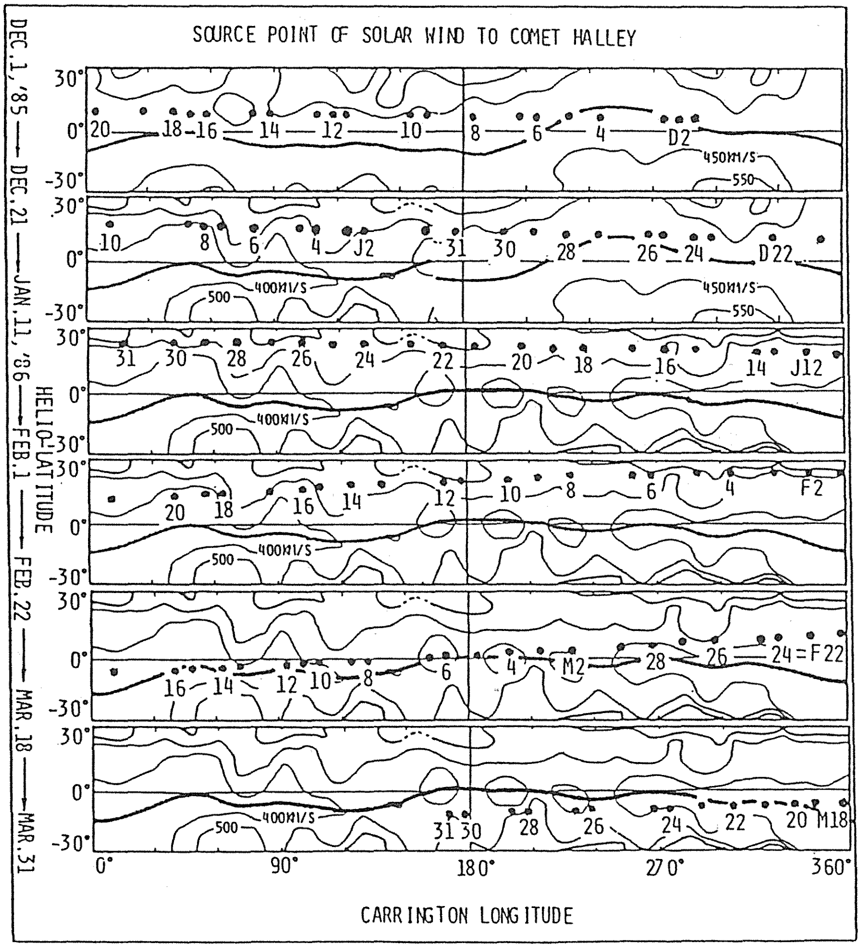

Fig. 7

magnetic polarity data measured by the Japanese spacecraft "SAKIGAKE" showed the multiple reversing of the polarity as shown in Figure 6 (Saito et al. 1986). This means that the comet did cross the neutral sheet during 10–11 March.

The overall structure of the heliomagnetosphere was inferred from the interplanetary scintillation (IPS) observation (Kojima et al., 1987). From the results we constructed Figure 7, which shows the shift of the source point from December 1985 to March 1986, where the source point on the solar synoptic chart means the point from which the solar wind starts and collide with comet Halley at the denoted date. The thin contour lines represent the solar wind velocity, which were obtained from the IPS data for solar rotation Nos. 1766–1769 for the 1985 December. synoptic charts and Nos. 1772–1774 for the 1986 charts respectively. From these contours we determined the location of the neutral line by connecting the minimum velocity points. The figure shows that comet Halley was very close or actually crossed the heliospheric neutral sheet around this period.

Therefore, if we take the dayside-crossing model (Niedner et al., 1978; Saito and Oki, 1988), the kink had to be a DE owing to the dayside reconnection associating with the neutral sheet crossing. But, if the disturbance was a DE, the velocity of the kink had to be accelerated more rapidly and abruptly. Contrary to this, if we take the ordinary flow model (Saito and Oki, 1988), the acceleration must be smooth and small. We compared our measurement in Figure 8 with the theoretical velocity curves which were obtained by Minami et al. (1986), Tomita et al. (1987) and Saito et al. (1987) for the cases of the ordinary flow and DE. It is remarkable that both the observational X–t and V–t values coincide quite well with the curves of the ordinary flow of the kink event. On the contrary, the curves show a large difference from the curve for the knot type DE that occurred on 31 December, 1985.

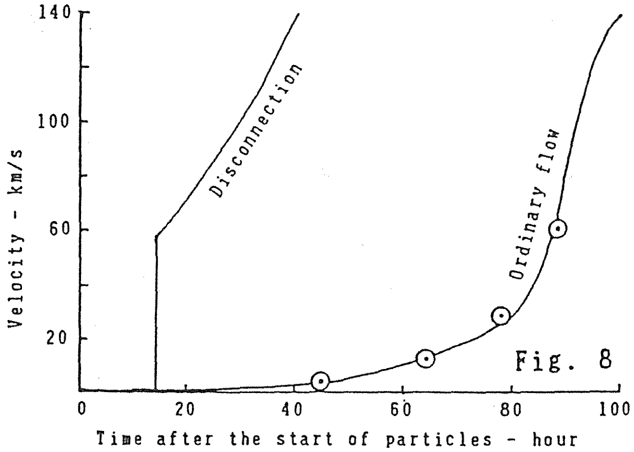

Fig. 8

5. Conclusion

Hence, we can conclude that this 12–14 March kink event can be explained not by DE, but the kink mechanism with the ordinary flow as the similar kink event on 10–11 January, 1986. About the formation mechanism of the January kink event, we proposed a wind shear model (Saito et al. 1989). However, in the case of the present kink event on 12–14, March 1986, we cannot find such a latitudinal wind shear in Figure 7 to explain this event. Therefore, a new interpretation may be necessary. We are considering two possible models on the formation of a kink; one is related to a crossing of comet through the heliomagnetospheric neutral sheet, and the other to a sudden increase of the solar wind speed. We will report on this problem in a future article.

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