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THE SOLAR WIND STRUCTURE THAT CAUSED A LARGE-SCALE DISTURBANCE OF THE PLASMA TAIL OF COMET AUSTIN

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OBSERVATION

The plasma tail of Comet Austin ($1989c_1$) showed remarkable disturbances because of the solar maximum period and its orbit. Figure 1 shows photographs of Comet Austin taken in Shibata, Japan, on April 29, 1990 UT, during about 20 minutes with the exposure times of 90 to 120 s. There are two main features in the disturbance; one is many bowed structures, which seem to move tailwards, and the other is a large-scale wavy structure. The bowed structures can be interpreted as arcade structures brushing the surface of both sides of the cometary plasma surrounding the nucleus. We identified thirteen structures of the arcades from each of the five photographs and calculated the relation between the distance of each structure from the cometary nucleus,x, and the velocity, v. The result is shown in Figure 2, which indicates that the velocity of the structures increases with distance. This is consistent with the result obtained from the observation at the Kiso Observatory which is shown by the open circles in Figure 2 (Saito et al., 1990).

SOLAR WIND STRUCTURE RESPONSIBLE FOR THE DISTURBANCE

According to the windsock theory (Brandt and Rothe, 1976), the direction of the cometary plasma tail is determined by the velocities of the solar wind and the orbital motion of the comet. Therefore, if the direction of the solar wind flow is radial from the sun, the plasma tail axis changes in the orbital plane of the comet with changes of the speed of the solar wind. From the large-scale configuration of the tail, the solar wind speed, v, as expected from the windsock theory is obtained with the nucleus-structure distance, x, as shown in Figure 3. Comparing this result with the observation, we find that the expected speeds are far smaller than the observed speeds, especially for $x > 2 \times 10^6$ km. Therefore the large-scale disturbance must be explained by a non-radial flow of the solar wind.

As proposed by Colburn and Sonett (1966) and Dessler (1967), a non-radial flow can be caused by a stream interaction between a high-speed flow and a low-speed flow. The non-radial flow has also been postulated observationally by Brandt *et al.* (1980) showing that the event of Comet Bradfield (1979l) on February 6, 1980 was caused by a change of the polar component of the solar wind flow by 50 km/s. Pizzo (1989) has reported a model of the variation of the solar wind parameters in the interaction region using a 2-D MHD simulation. When the speed and the direction of the solar wind change as shown in Figure 4a (Pizzo, 1989), the simulation shows a deformation of the plasma tail as in Figure 4b (Kozuka *et al.*, 1990). For the Comet Austin event, we deduced the solar wind structure from the deformation of the wavy structure of the plasma tail observed for 21 min 42 s. The result is shown in Figure 5. It suggests that a velocity discontinuity in the solar wind crossed the comet.

The non-radial flow in the solar wind discussed above must have originated in some solar phenomenon. We found no solar flares responsible for the large-scale cometary disturbance on that date. Another possible cause is that the comet crossed the heliospheric neutral sheet. The source point of the solar wind flow which was to pass by the comet that day was located on the solar source surface. Since the distance from the source point to the nearest neutral line is as far as 56°

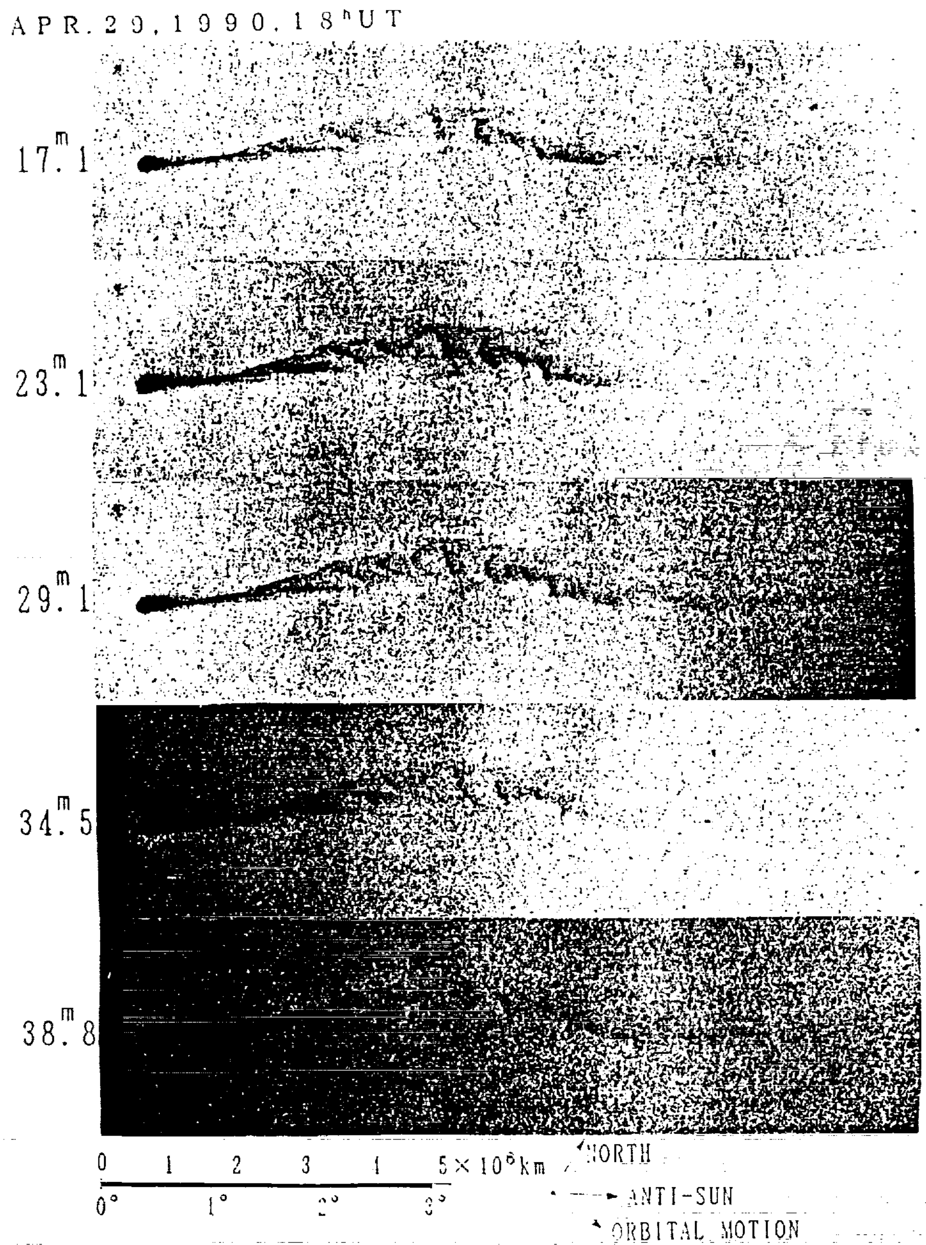


Fig. 1. – The plasma tail of Comet Austin taken in Shibata, Japan, on April 29, 1990 UT, with exposure times of 90 to 120 s. There are many bowed structures and a large-scale wavy structure.

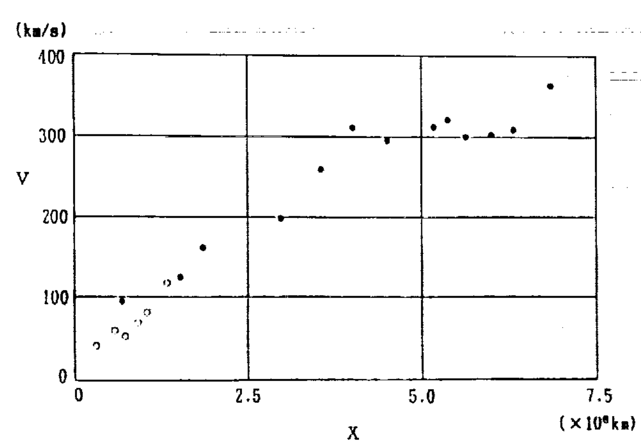


Fig. 2. – Relation between the velocity of the structures and the distance from the nucleus.

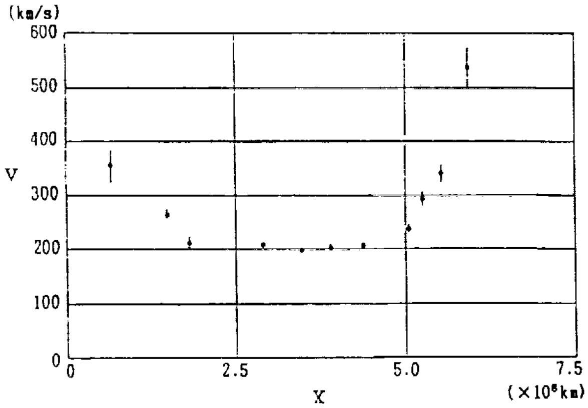


Fig. 3. – Solar wind speed expected from the windsock theory.

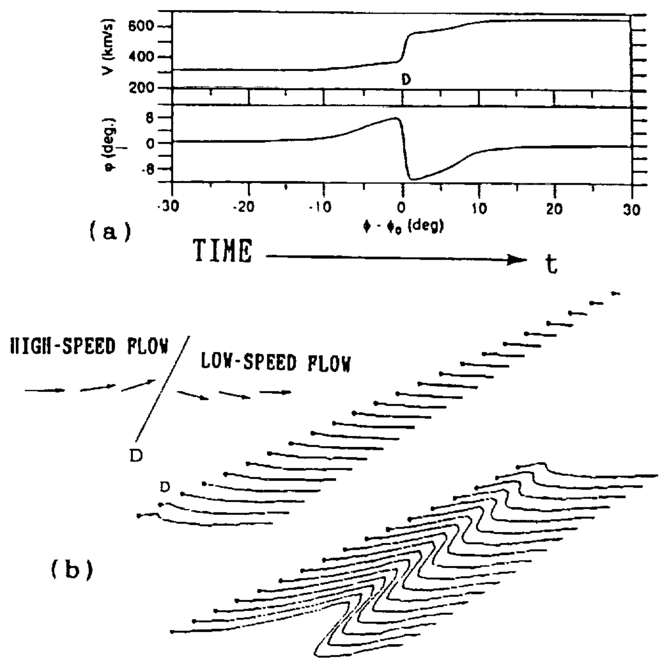


Fig. 4. – (a) Two-dimensional MHD simulation showing the variation of the solar wind parameters by a corotating stream (Pizzo 1989). (b) Tail-bending simulation.

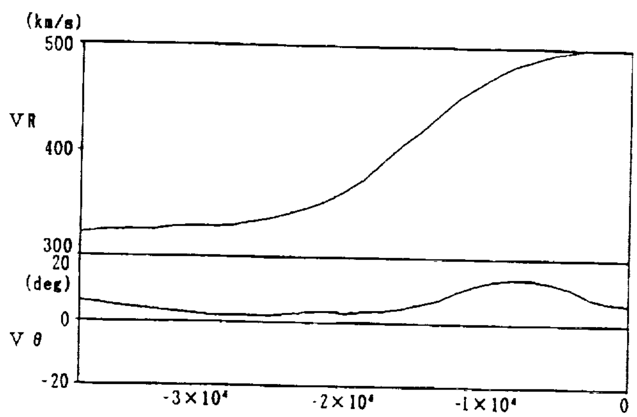
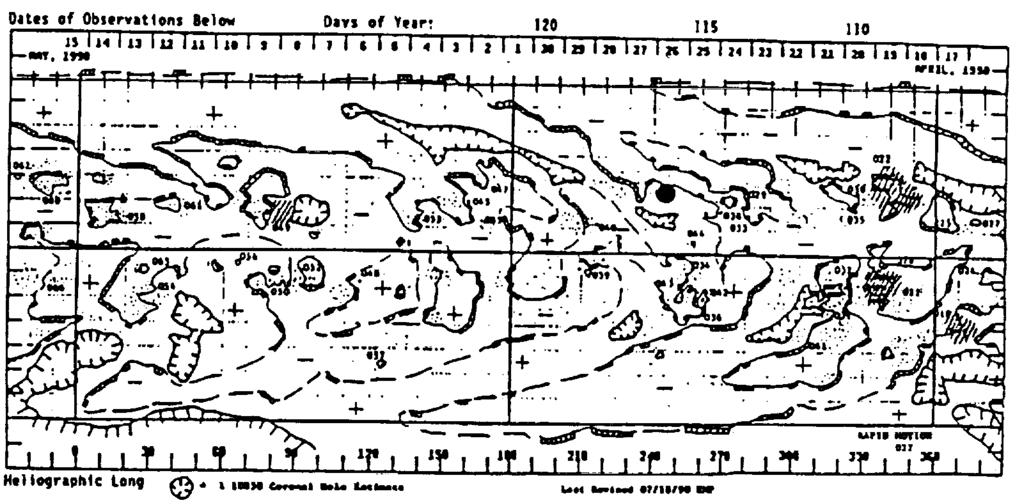


Fig. 5. – Solar wind velocity obtained from the deformation of the tail.



● SOURCE POINT OF THE SOLAR WIND EXPECTED TO ATTACK THE COMET

Fig. 6. – Various solar phenomena expressed by the H-alpha solar synoptic chart (Carrington rotation number 1828, 18 April to 15 May 1990) for the cometary disturbance.

in longitude, it is concluded that this cometary event was not caused by the comet crossing the neutral sheet.

Finally, we surveyed the photospheric H-alpha synoptic chart shown in Figure 6. We found that a coronal hole existed near the source point. Consequently, it is quite possible that the disturbance was caused by a stream interaction between the high-speed flow from the coronal hole and the low-speed flow from the western region. Figure 7 shows the geometrical relation between the Sun, the Earth, and Comet Austin on April 29, 1990 on the meridian plane and the ecliptic plane. The comet was at the position where we could look up the Parker's spiral from the Earth. It must be concluded then, that the deflection of the solar wind flow in the corotating stream interaction region caused by the coronal hole matches quite well with the observation.

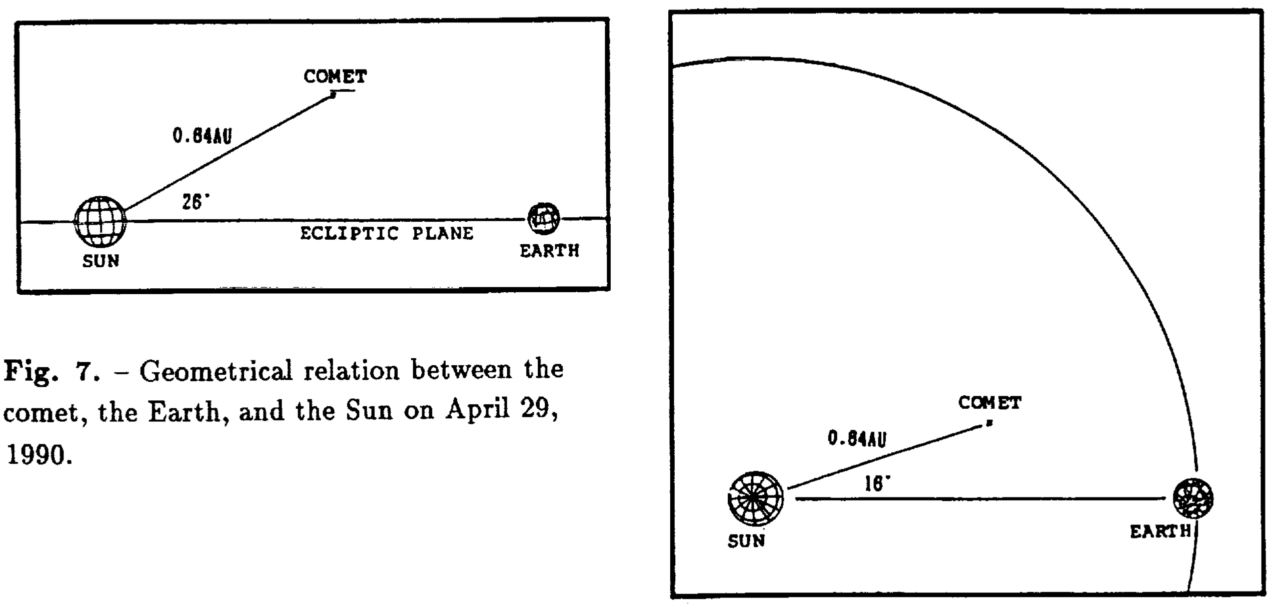


Fig. 7. – Geometrical relation between the comet, the Earth, and the Sun on April 29, 1990.

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