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# MOSAIC CCD METHOD: A NEW TECHNIQUE FOR OBSERVING DYNAMICS OF COMETARY MAGNETOSPHERES

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## OBSERVATION

On April 29, 1990, we observed the plasma tail of Comet Austin with a CCD camera on the 105-cm Schmidt telescope at the Kiso Observatory of the University of Tokyo. The area of the CCD used in this observation is only about 1 $cm^2$. When this CCD is used on the 105-cm Schmidt telescope at the Kiso Observatory, the area corresponds to a narrow square view of $12' \times 12'$. By comparing with the photograph of Comet Austin taken by Numazawa (personal communication) on the same night (see Figure 1), we see that only a small part of the plasma tail can be photographed at one time with the CCD. However, by shifting the view on the CCD after each exposure, we succeeded in imaging the entire length of the cometary magnetosphere of $1.6 \times 10^6$ km. We call this new technique "the mosaic CCD method". In order to study the dynamics of cometary plasma tails, we imaged seven frames of the comet from the head to the tail region twice with the mosaic CCD method and obtained two sets of images as shown in Figure 2.

## ANALYSIS

In Figure 2, six microstructures, including arcade structures, were identified in both the images. Figure 3 shows sketches of the plasma tail including microstructures.

The relation between the travel speed of the structure $v$ and the distance of the structure from the nucleus projected onto the tail axis $x$ is shown in Figure 4. The flow speed of the plasma very close to the coma was obtained for the first time from this observation. The $x - v$ relation obtained by Minami and White (1986),

$$v(x) = \{v_0[cosh(x/x_0) - 1] + v_n\}/cosh(x/x_0), \tag{1}$$

holds here and we have found that at $x = 0$, the flow velocity has a non-zero value, $v(0) = v_n = 35 \pm 5$ km $s^{-1}$. This velocity is much larger than the thermal velocity $v_{th} \sim 1 - 2$ km $s^{-1}$, which had been expected near the nucleus. A new interpretation is now needed to explain this observational result.

## MODEL

We can explain the non-zero value of the flow velocity at the nucleus by a 3-D model of the cometary magnetosphere as shown in Figure 4. The figure on top is the view of the cometary magnetosphere seen from the equatorial plane and the figure on bottom is the view from the pole. The solar magnetic field stagnates in front of the cometary plasmapause and after winding around the plasmasphere, it passes through its side as shown in the figure by $a - b - c - d$. Therefore, the plasma has non-zero velocity when it crosses the Earth-comet line or at the apparent nucleus position ($x = 0$). The plasma winding around the magnetic lines is probably seen as arcade structures from the Earth as seen in Figures 2 and 3.

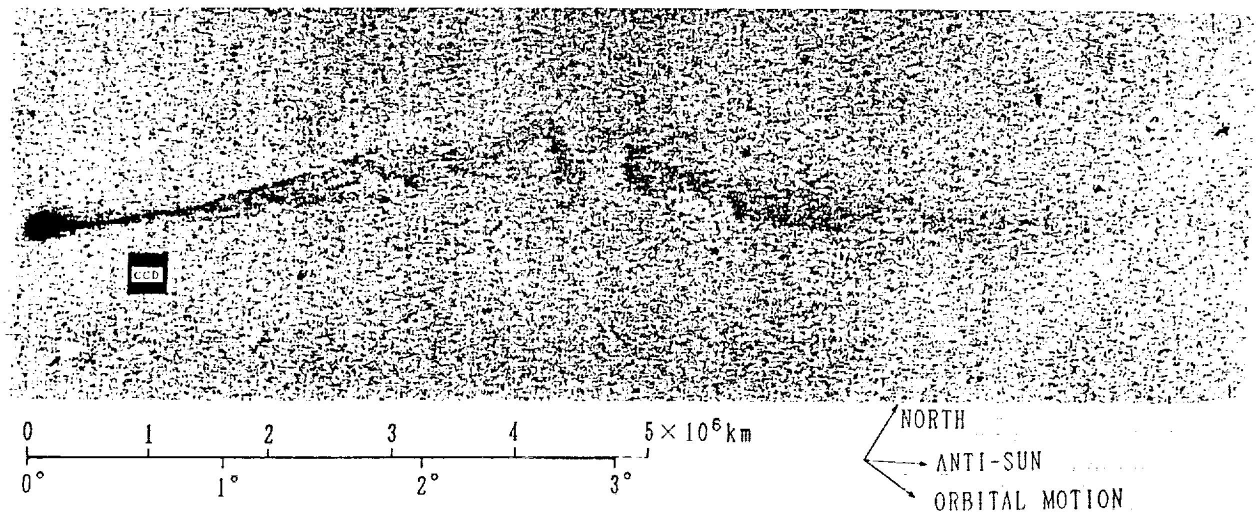


**Fig. 1.** – Comparison of the scale of the plasma tail of Comet Austin on April 29, 1990, taken by S. Numazawa and the size of the CCD used for the observation in this work.

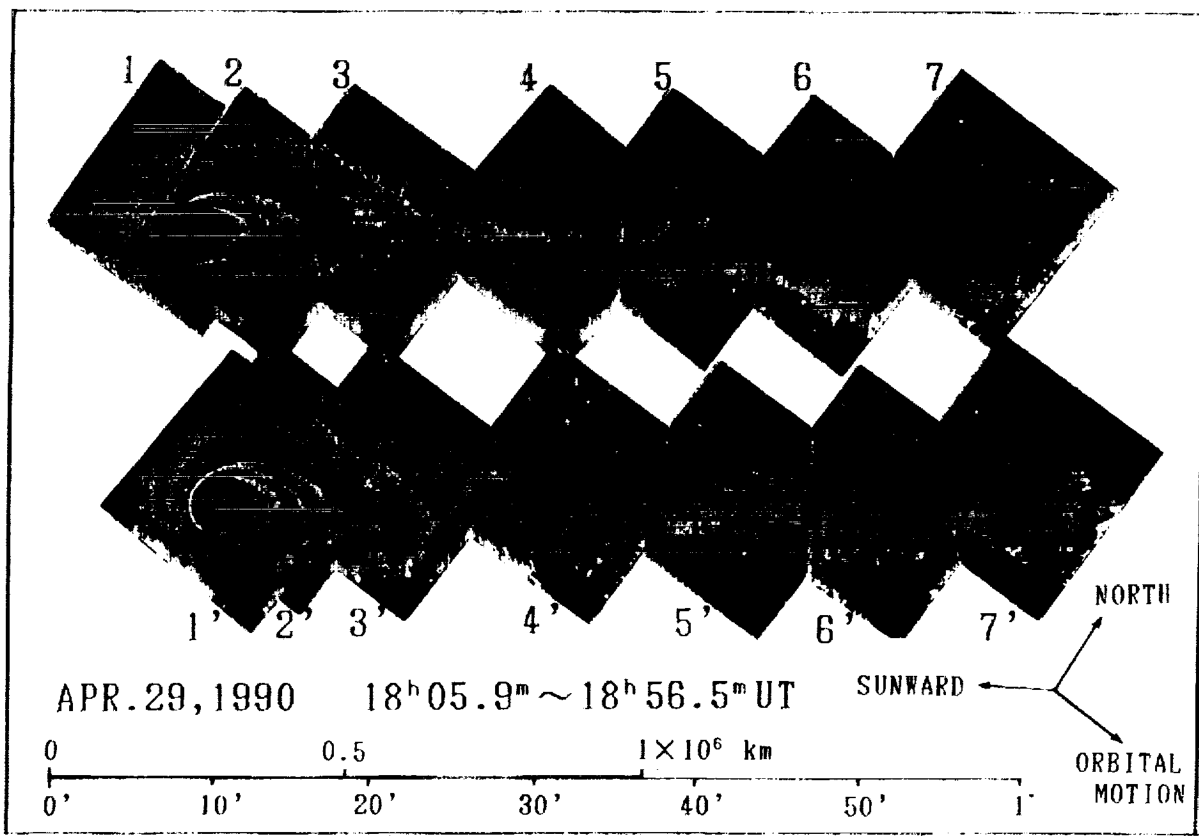


**Fig. 2.** – The plasma tail of Comet Austin on April 29, 1990, obtained with "the mosaic CCD method". Seven frames of the comet from the head to the tail region were imaged twice.

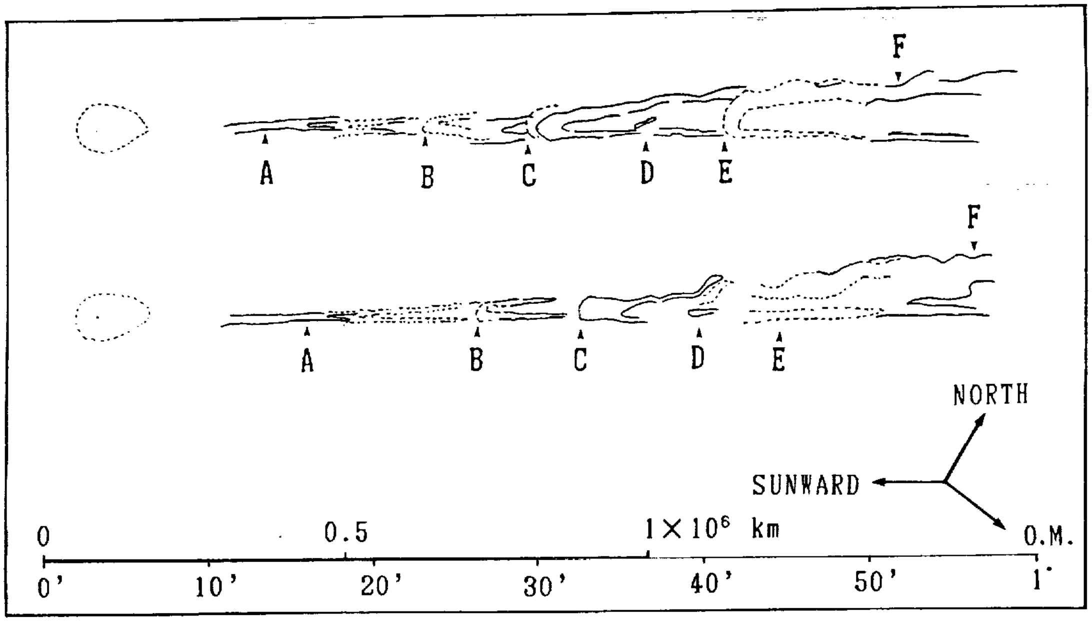


**Fig. 3.** – Sketches of the plasma tail of Comet Austin made from Fig. 2. Six microstructures, including arcade structures, were identified in both the images.

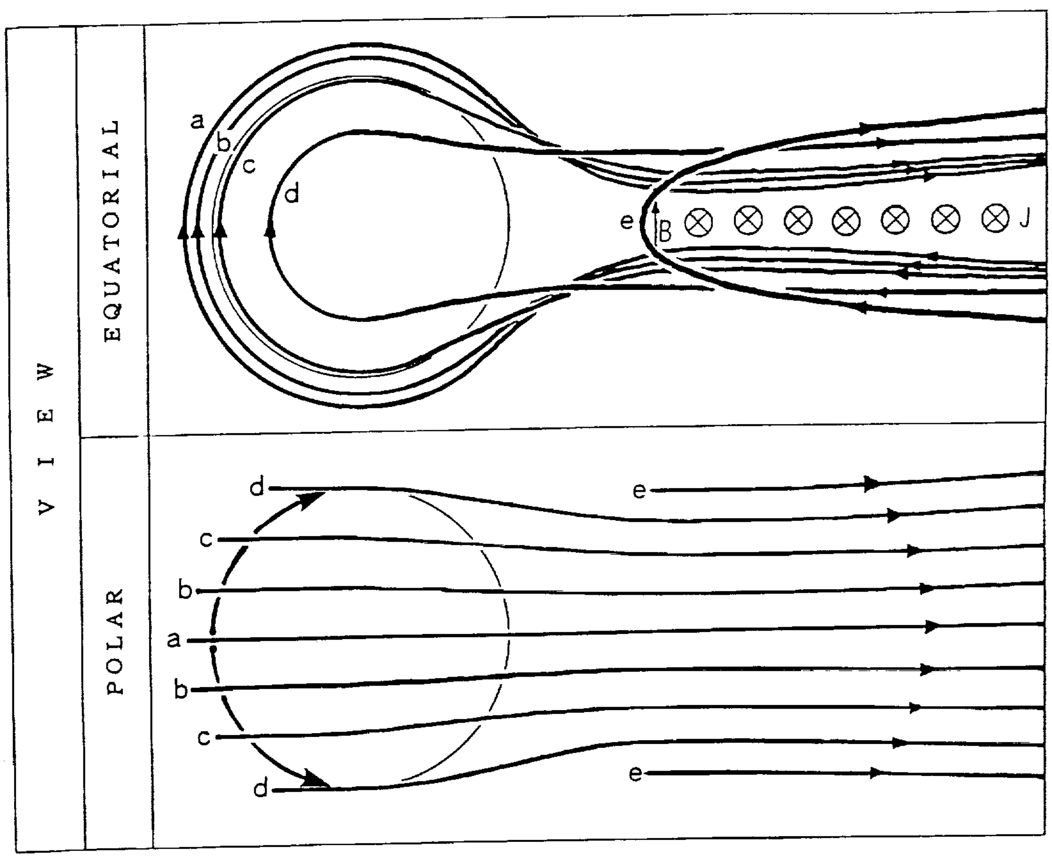


**Fig. 4.** – Equatorial and polar views of the 3-D model of the cometary magnetosphere. The solid lines are solar magnetic field lines. They stagnate in front of the cometary plasmapause and after widing around the plasmapause, they pass through the side as $a - b - c - d - e$.

## PLASMA FLOW ALONG THE DAYSIDE PLASMAPAUSE

The model suggests that the plasma flow in the dayside plasmapause stagnates at the position shown in Figure 5 having non-zero velocity $v_s$ in the azimuthal direction and that it is under constant acceleration $a$ along the plasmapause and passes by its side. The $x - v$ relation in the $x < 0$ region becomes

$$v(x) = \{[2aRcos^{-1}(x/R) + v_s^2][1 - (x/R)^2]\}^{1/2}, \tag{2}$$

where $a$ is the acceleration of the plasma flow and $R$ is the radius of the plasmapause. The plot of $v$ as a function of $x$ and for $v_s = 20$ km s$^{-1}$ and $R = 2 \times 10^5$ km is shown by a dotted line in Figure 5.

### Reference

Minami, S., and White, R.S. (1986) An acceleration mechanism for cometary plasma tails. Geophys. Res. Lett., 13, 849-852.

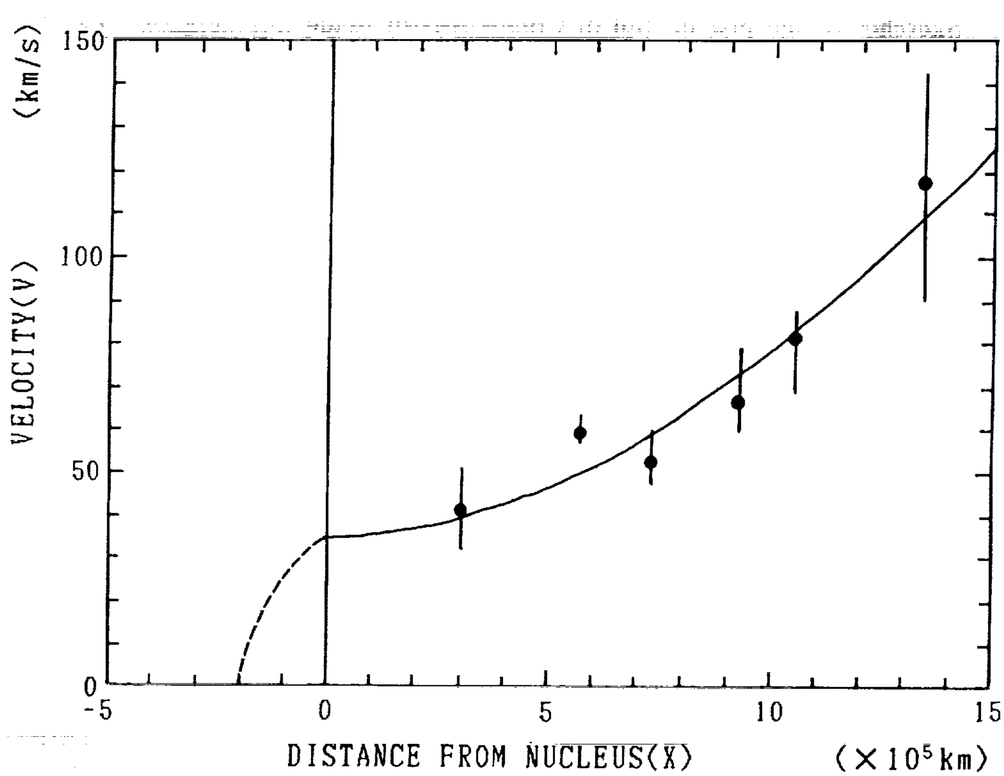


**Fig. 5.** – The velocity of the plasma flow in Comet Austin as a function of cometocentric distance. The dotted line shows the velocity calculated from the $x - v$ relation by Minami and White (1986) as shown in equations (1) and (2).