Rapid Change of the Plasma Tail of C/2013 R1 (Lovejoy)

YAGI, Masafumi (NAOJ)
KODA, Jin (Stony Brook University)
FURUSHO, Reiko (Tsuru University/NAOJ)
KOYAMA, Yusei, KODAMA, Tadayuki (NAOJ/SOKENDAI)
YOSHIDA, Michitoshi (Hiroshima University)

In Dec. 2013, we had a time in morning twilight in an open use program of extragalactic objects with the Subaru Prime Focus Camera. As a bright comet (C/2013 R1 (Lovejoy)) was seen, we took its image in I-band and V-band for educational and public outreach purposes. We then found that the shape of the plasma tail changed in a few minutes [1].

The comet was at 0.55 au from the earth, and sun-comet-earth angle was 83°.2 at the observation time. We observed the plasma tail nearly edge-on, which is an ideal condition for the study on the time variation of the structure of the tail. The physical scale of the tail was about 400 km/arcsec considering the slight inclination.

We quantitatively evaluated two changes of the shape, which were first visually identified; a motion of two knots in the tail and the change of the width of the tail. The knots was detected and measured in unsharp-masked images after masking of elongated background stars (Figure 1). In plasma tails of comets, we observe CO^+ and H_2O^+ in I-band, while mainly CO^+ in V-band. Thus the difference of shapes in I- and V-bands may be due to the difference of distribution of these ions. We however consider that the same knots were observed in I and V-bands, because the motion of the two knots in the I- and V-bands lie on the same relation as shown in Figure 2. The speed of them are 20, 25 km/s along the tail, and 3.8, 2.2 km/s across the tail. The speed of knots along the tail would correspond to the speed of the flow of the plasma tail. The change of the width is then measured in I-band, considering the flow speed, and it was 8 km/s at each side in 8 minutes (from the start of the first exposure to the end of the last exposure).

In Table 1, the speed of structures in plasma tails along the tails in literature are summarized. The speed obtained in this study, ~22 km/s, are less than half of the previous studies. As we observed the knots near to the nucleus (~300,000 km), the value may reflect the initial speed of the tail before the acceleration by the solar wind. However, three times larger speed was obtained in study of 1P/Halley at a comparable distance from the nucleus. We need to accumulate the data in order to identify what is the key parameter to the speed; size of the structure, solar activity, ecliptic latitude, solar distance of the comet, etc. Efficient observation strategy is required including a use of large telescopes.

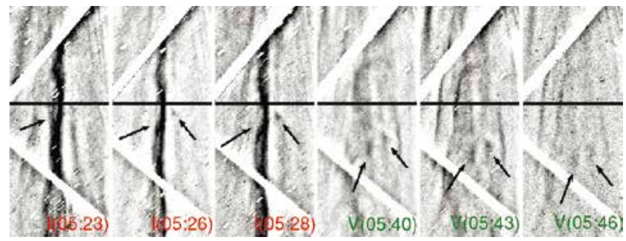

Figure 1: Cutouts of unsharped masked images of the comet tail. The nucleus to the top, the plasma tail is along y-axis, and the two arrows show the knots. Six exposures were shown in order of time from the left to the right. Black horizontal line indicates 300,000 km distance from the nucleus. The knots moved downstream.

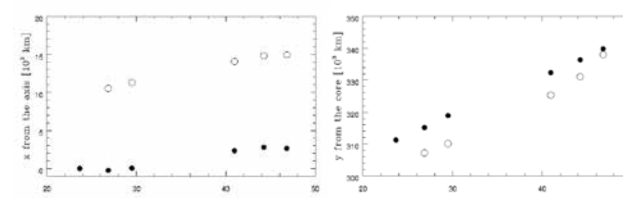

Figure 2: Motion of the two knots. Open and filled circle correspond to each knot. The left panel shows motion across the tail, the right along the tail. Left three data points are in I-band, and right three are in V-band.

comet	speed	Distance from nucleus
various [2]	44±10.9 km/s	< 10^7 km
1P/Halley [3]	65.8 km/s	$4-9\times10^5$ km
C/1996 B2 [4]	99.2 km/s	$\sim5\times10^6$ km
C/1995 O1 [5]	500 km/s	$\sim7\times10^7$ km
C/2001 Q4,		
C/2002 T7 [6]	50−100 km/s	$\sim10^6$ km
C/2013 R1 (this work)	20−25 km/s	$\sim3\times10^5$ km

Table 1: Speed of structures in comet tails.

References

[1] Yagi, M., et al.: 2015, *AJ*, **149**, 36.
[2] Niedner, M. B. Jr.: 1981, *ApJS*, **46**, 141.
[3] Saito, T., et al.: 1987, *A&A*, **187**, 209.
[4] Kinoshita, D., et al.: 1996, *PASJ*, **48**, L83.
[5] Brandt, J. C., et al.: 2002, *Earth, Moon, and Planets*, **90**, 15.
[6] Buffington, A., et al.: 2008, *ApJ*, **677**, 798.