Comet Liller 1988 V and solar wind

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Abstract. A set of four large-scale exposures of comet Liller 1988 V taken between 1988 May 5 and May 10 is evaluated. The observations were obtained with the 63/85/ 187 cm Maksutov telescope of the Kleť Observatory. The studied plasma tail is slightly fuzzy due to the projection on the dust tail. The length of the plasma tail on the best picture of May 7 is at least 1.5°.

For this period the solar wind velocity was determined from the aberration angle of the plasma tail in the cometary environment. This value of the solar wind velocity is compared with the satellite data recorded near the Earth.

Key words: comet — plasma tail — solar wind

1. Introduction

The long-period comet Liller 1988 V had, at the first observed return, a visible plasma tail. The comet was observed from 1988 January 12 to 1988 July 14 (Marsden and Williams, 1992). We have used a set of four large-scale exposures of comet Liller 1988 V (Table 1) to study the solar wind in the comet's environment.

Table 1. Observations of comet Liller 1988 V.

No.	Exposure	Exposure time	Observer
	1988	min	
1	May 5.91230	17	A. Mrkos
2	May 6.86875	20	A. Mrkos
3	May 7.87074	19	A. Mrkos
4	May 9.86588	20	A. Mrkos

The plates were exposed between 1988 May 5 and 10 in the Maksutov 630/850/1870 mm telescope of the Kleť Observatory on ORWO ZU-21 plates. The exposure time of the plates was between 17 and 20 minutes (see Table 1).

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2. Comet's motion

The long-period comet Liller 1988 V moves in an elliptical orbit with an eccentricity of 0.996565 in a plane inclined at 73.31710°. The perihelion of the orbit is 25.92° above the ecliptic plane, 0.84 AU from the Sun. The comet passed it on 1988 March 31.11 ET.

The relative positions of the comet, Sun, and Earth between 1988 May 5 and 10 are shown in Figure 1. The comet was 50.34–51.44° above the ecliptic, 1.07–1.11 AU from the Sun, and 1.23–1.22 AU from the Earth. At these heliocentric distances the comet latitudes correspond to positions 0.82–0.87 AU above the ecliptic, 73.52–82.89° in ecliptical longitude. The phase angle Sun—comet—Earth was 55.87–58.89°, the Earth's longitude 225.60–229.43°.

Within the period investigated, i. e. 1988 May 5 and 10, the positional parameters of the comet, Sun, and Earth varied as listed in Table 2.

Table 2. Positional parameters of the comet, Sun, and Earth.

Exposure 1988 May	(UT)	5.912	6.869	7.871	9.866
Distance comet–Sun	(AU)	1.066	1.077	1.088	1.110
Distance comet–Earth	(AU)	1.229	1.226	1.223	1.218
Distance Earth–Sun	(AU)	1.009	1.009	1.009	1.010
Distance comet–ecliptic plane	(AU)	0.821	0.833	0.845	0.868
Angle Sun–Earth–comet	(deg)	55.872	56.615	57.385	58.890
Angle Sun–comet–Earth	(deg)	51.556	51.497	51.410	51.156
Right anomaly of comet	(deg)	54.733	55.798	56.891	59.002
Ecliptical longitude of comet	(deg)	73.523	75.726	78.080	82.887
Ecliptical latitude of comet	(deg)	50.341	50.671	50.975	51.443
Ecliptical longitude of Earth	(deg)	225.604	226.530	227.499	229.429

3. Plasma tail

On all four plates taken between May 5 and 10, the plasma tail is clearly visible. Its length varies from 0.5° to 1.5° due to different exposure times and atmospheric conditions during the observational period. The plasma tail is not uniformly structured and on all plates it is "obscured" by a diffuse component of a dust tail. There is only one picture (May 7) with some indications of structures observed in the plasma tail, but no kinks or condensations were detected.

4. Solar wind and plasma tail

The deviation of the axis of the comet plasma tail from the comet–Sun radius vector, the so-called aberration angle, is due to the mutual interaction of the tail's plasma with the solar wind flow, the value of which is proportional to

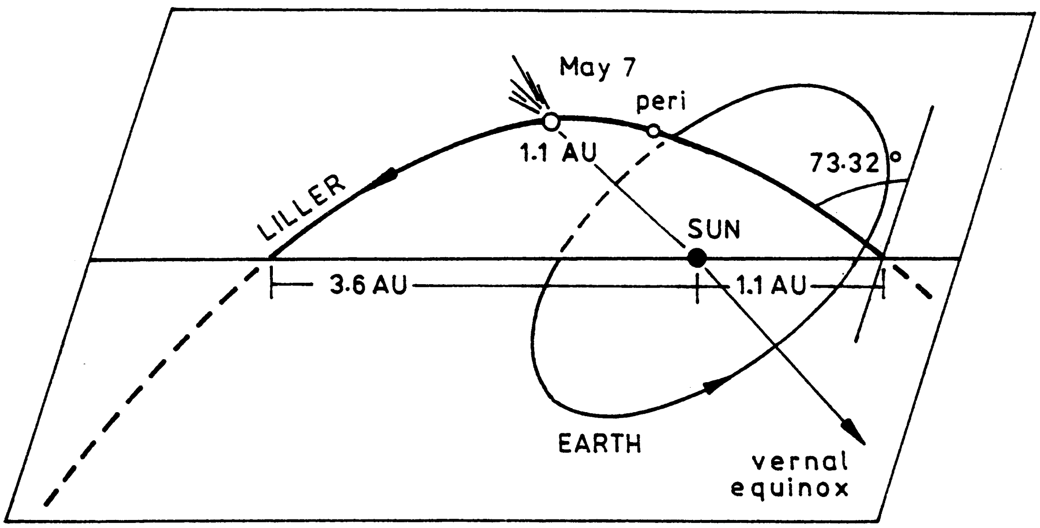

Figure 1. Relative position of comet Liller 1988 V, the Sun, and the Earth on 1988 May 7.

the wind velocity. This problem, together with the related topics, such as the motion of the plasma kinks or condensations, disconnection events, and many others have been discussed in several papers, e. g. Brandt (1969), Jokers and Lüst (1973), Niedner *et al.* (1978), Tarashchuk (1974), Saito *et al.* (1986a, 1986b), Watanable *et al.* (1986, 1987), and in many lectures, presented at symposia or colloquia devoted to cometary research.

It is impossible to figure out the solar wind velocity vector from the measurements of the tail aberration angle alone. The problem could be solved by assuming a purely radial solar wind flow. In the first approximation, the tangential component of the solar wind is zero. Given the radial velocity component of the solar wind, one could estimate the minimum value of its tangential component. The velocity of the plasma tail ions, carried along the lines of force of the solar and interplanetary magnetic field, does not correspond to the solar wind velocity, because the velocity of ions is reduced by the kinetic energy required to carry away the dust particles (Tarashchuk 1974). Therefore, the solar wind velocities calculated from the measurements of aberration angles, using the formulae of Jockers *et al.* (1972), listed in Table 3, should be considered as their minimum estimates.

The last two columns in Table 3 give the minimum value of the tangential component of the solar wind velocity under the assumption that the radial velocity component is 300 km/s and 600 km/s, respectively. As mentioned above, this is only the minimum value, because the deviation angle of the solar wind velocity vector from the comet's orbital plane is unknown. The tabulated values of the tangential velocity component are marked + if the aberration angle is increased by the tangential velocity component of the solar wind, and − in the opposite case. As seen from Table 2 and 3, the values of the radial velocity

Table 3. Solar wind flow velocity between 1988 May 5 and 10.

No.	Date middle of exposition UT	Aberration angle	Solar wind flow velocity minimum radial tangential = 0	minimum tangential radial = 300	radial = 600
	1988 May	deg	km/s	km/s	km/s
1	5.912	2.4	329	17.6+	27.4+
2	6.869	1.3	598	14.3+	19.6+
3	7.871	1.4	586	15.1+	20.9+
4	9.866	1.7	533	17.2+	24.2+

Ecliptical longitude 74–83°, latitude 50–51°, heliocentric distance 1.1 AU.

increase from about 330 km/s to 600 km/s between 1988 May 5.91 and 6.87 at practically the same value of the ecliptical latitude of the comet and the same heliocentric comet's distance. After May 7 the radial velocity of the solar wind decreased.

The quantities used to determine the solar wind velocity — equatorial coordinates of the Sun and the comet, ecliptical longitude and cometocentric coordinates of the Earth, the comet's orbital velocity components, equatorial spherical coordinates, and tabulated values - were calculated using our own computer programs. The coordinates of the comet were calculated using the orbital elements as determined by Green (1988). The radial direction from the Sun to the comet was determined by the method of the great circle crossing the Sun and the comet (Dobrovolskij, 1966).

To determine the aberration angle from the plates, the coordinate frame of the exposures was provided by 98 reference stars from the Smithsonian Astrophysical Observatory Star Catalogue, with due correction for their proper motion.

5. Solar wind from satellite data

During the investigated period, 1988 May 5 and 10, the comet moved in the region 0.821–0.868 AU above the ecliptic, in ecliptical longitude from 73.52° to 82.89°, and at heliocentric distances from 1.07 AU up to 1.11 AU. The magnetic interplanetary field parameters within this period are plotted in Figure 2. They were taken from the data collected by the IMP-8 satellite (King, 1989), which operates at a distance of 30–40 Earth radii from the Earth.

Comparison of the data in Table 2 with those in Figure 2 shows that our measurements fit the satellite data of the solar wind velocity quite reasonably. There is no correlation between the total interplanetary magnetic field magnitude and the solar wind velocity data. Only the first peak of the solar wind velocity on May 6.4, 650 km/s, correlates with the maximum of the total interplanetary magneticA field magnitude. The second peak of the solar wind velocity on May

7.8 is accompanied by the local minimum magnitude of the total interplanetary magnetic field. Generally, the satellite data show that the solar wind velocity decreases more slowly than the magnitude of the total magnetic field.

It is generally agreed that there is a strong interaction between the solar wind and cometary plasma. Yet, the details of this coupling still remain rather obscure and are the subject of discussion (Mendis and Houpis, 1982; Mingchan and Puzhang, 1986).

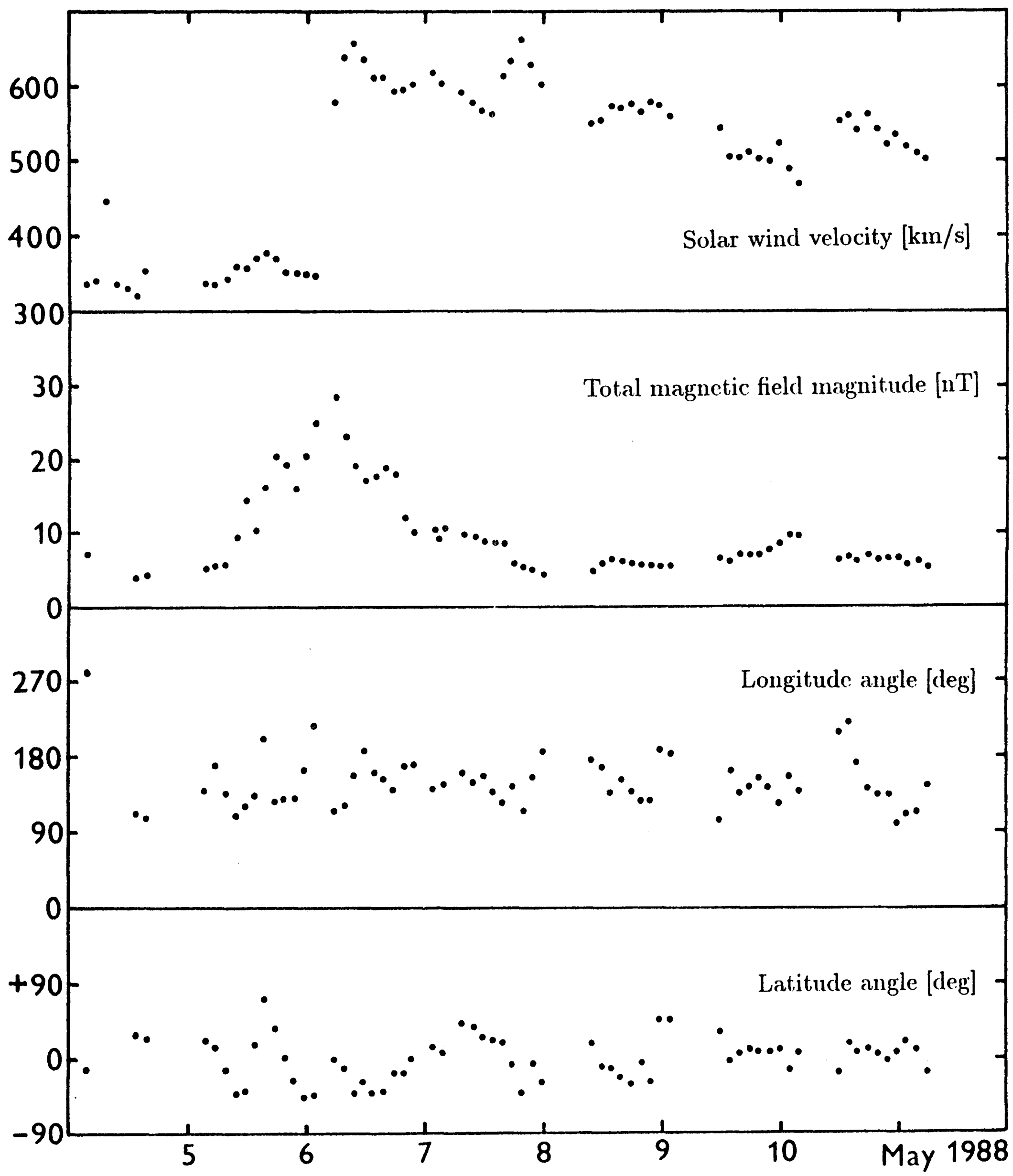

Figure 2. The satellite (IMP–8 spacecraft) solar wind and magnetic field data.

6. Conclusions

All four large-scale exposures of the comet Liller 1988 V taken between 1988 May 5 and 10 reveal the distinct plasma tail, the length of which varied from 0.5° to 1.5° in dependence on the exposure time, and the current conditions of observation. Within this period the estimates of minimum values of the radial component of the solar wind velocity, as determined from the aberration angles of the ion tail, were in the range from 329 km/s to 598 km/s.

The corresponding minimum values of the tangential components for the same period varied between 17.6 km/s and 14.3 km/s and 27.4 km/s and 19.6 km/s, under the assumption that the radial velocity component was 300 km/s and 600 km/s, respectively. These values were determined for the region 0.82–0.87 AU above the ecliptic plane, in the longitude interval 73.52–82.89°, at a distance of 1.07–1.11 AU from the Sun. There are some indications that around May 5–6, the comet probably passed through the magnetic sector boundary of the interplanetary magnetic field. For this comet we found no large difference between the solar wind velocity in the region of the Earth and in the comet's environment.

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