THE PHOTOMETRIC STUDY OF THE PLASMA TAIL OF COMET HYAKUTAKE (C/1996 B2)

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The brightness distribution for the plasma tail of Comet Hyakutake is obtained. The photometric scans along the unusually long jet directed at the tail side are studied. The photometric scans along the main streams in plasma tail are compared with the brightness profiles calculated on the basis of the diffusion model of the plasma tail. The magnetic field induction and the lifetime of ions in the tail of Comet Hyakutake as well as the coefficients of diffusion are estimated.

OBSERVATION AND PHOTOMETRIC TREATMENT

The image of Comet Hyakutake was obtained on March 23.917, 1996 with the DShA-astrograph (400/2000) of the Golosiiv Observatory, when the comet was near the Earth, only at 0.111 AU. The visible tail of the comet extended to more than 100° on the sky. On the plate 30×30 cm the image of comet occupies a greater part of the place. The image of the comet was obtained on the ORWO ZU-21 plate without filter. The surface photometry of comet tail was performed at the MAO NASU with ATsMF-XY digitizer by V. L. Kostiuchenko and V. G. Parusimov. The photometric treatment procedure let us to eliminate the regular photometric errors of the telescope as well as the difference into the atmospheric extinction along the tail. We calibrated the plate with standard stars from a photometric catalogue. The photometric treatment of the comet image was completed with the drawing of the brightness distribution map.

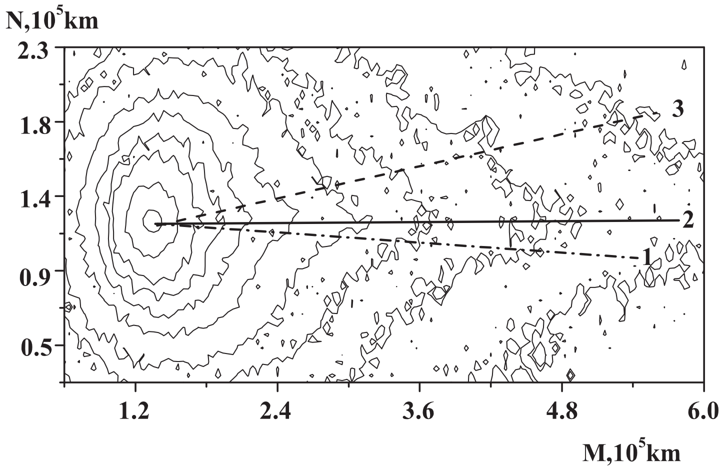

Figure 1. The isophotes of the tail of Comet Hyakutake on March 23.917, 1996. The dashed lines show the directions of photometric scans along the streams

Figure 1 shows the distribution of brightness of the plasma tail of Comet Hyakutake on March 23.917, 1996. The axis M on the brightness map is directed along the projection of the prolonged comet–Sun line and the axis N directed to the side where the aberration angle increases. For our study we obtained photometric scans along the directions which are marked in Fig. 1 by dashed lines. These directions are the axes of streams of the plasma tail. The other photometric scans were obtained along the transversal directions.

CALCULATION OF BRIGHTNESS PROFILES

The obtained scans were compared with the brightness profiles calculated with the well-known diffusion model of plasma tail [3]. Another work [5] in this issue discusses the improvement of the model. In this work we used the same method for estimation of the acceleration comet ions. Our earlier results [4] give the estimate of acceleration as $a = 52$ cm s^{-2}.

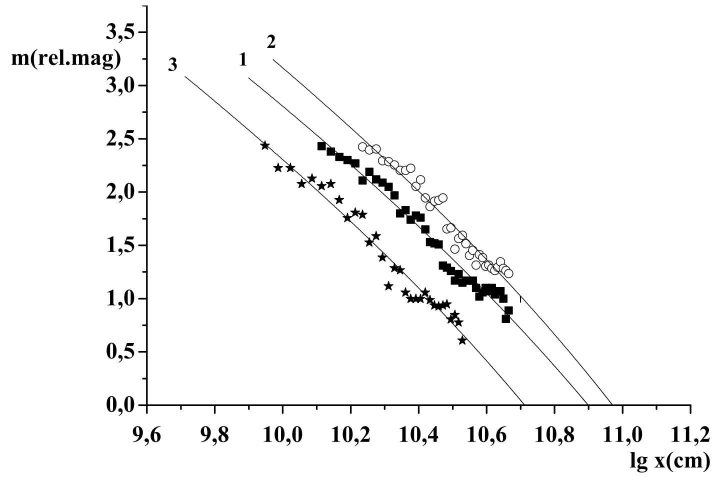

Figure 2. The photometric scans along the main streams of tail and the calculated profiles for the plasma tail of Comet Hyakutake on March 23.917, 1996

It will be noted that we took the estimate of ion's temperature from [6]: $T_i = (2 \div 8) \cdot 10^4$ K. Figure 2 shows the photometric scans and calculated profiles of brightness distribution along the streams of plasma tail on March 23.917, 1996. The chains of marks show the observed scans along the streams. The solid lines show the calculated profiles. The line numbers correspond to the stream numbers in Fig. 1. The brightness profiles along the streams in plasma tail are calculated with two model parameters: Γ and $L_{\parallel}$. The best fit of the profiles gives the values of these parameters for the each stream. Then, we found the best fit of transversal profiles of each stream of the plasma tail. This fitting gave the second scale factor, $L_{\perp}$.

Figure 3 shows the result of this fitting for the tangential scans of the main stream of plasma tail.

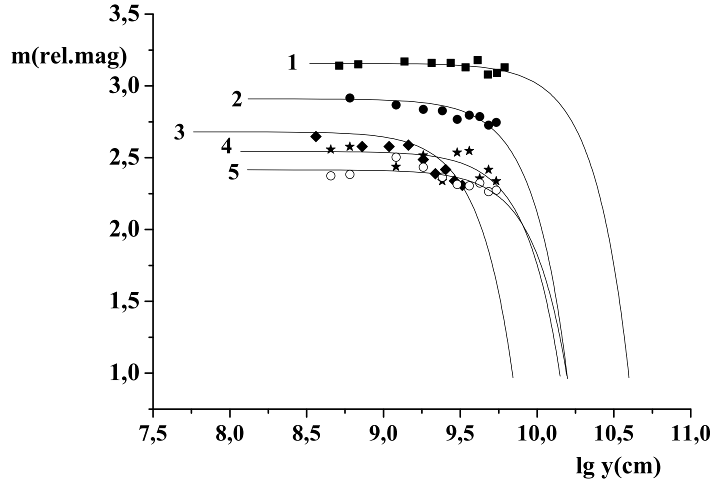

Figure 3. The tangential photometric scans of the stream 2 of tail and the calculated profiles for the Comet Hyakutake on March 23.917, 1996: (1) tangential scan at a distance of $1.72 \cdot 10^{10}$ cm from the nucleus, (2) at a distance of $2.13 \cdot 10^{10}$ cm, (3) at a distance of $2.72 \cdot 10^{10}$ cm, (4) at a distance of $3.21 \cdot 10^{10}$ cm, (5) at a distance of $3.79 \cdot 10^{10}$ cm

RESULTS

We obtained the sets of model parameters for three streams of plasma tail from comparison of the photometric scans and calculated profiles. The parameters were chosen by the criterion of the minimum deviation of calculated profiles from the photometric scans.

Table 1. Parameters of diffusion model for the tail of Comet Hyakutake

Stream	Γ	$L_{\parallel}$, 10^{10} cm	$L_{\perp}$, 10^{9} cm
1	4.26	0.793	6.13±1.48
2	3.27	0.935	10.19±2.22
3	4.17	0.515	4.69±0.94

Table 1 gives a set of model parameters. The parameter $L_{\perp}$ is calculated as the mean value of the parameters for some tangential profiles of streams of the tail. We used these parameters for calculation of physical characteristics of the plasma tail of Comet Hyakutake with the formulas from [1]. The lifetime τ of comet ions, coefficients of longitudinal diffusion $D_{\parallel}$, transversal diffusion $D_{\perp}$, and induction of magnetic field B for the plasma tail of Comet Hyakutake are in Table 2.

Table 2. Physical characteristics of the plasma tail of Comet Hyakutake

Stream	τ, 10^{4} s	$D_{\parallel}$, 10^{15} cm^2 s^{-1}	$D_{\perp}$, 10^{15} cm^2 s^{-1}	B^{min}, nT	B^{max}, nT
1	1.61	0.45	0.34	12.0	48.2
2	1.93	1.03	1.35	4.4	17.4
3	2.00	0.93	0.46	6.8	27.2

The analysis of the data of Table 2 shows that the coefficient of longitudinal diffusion $D_{\parallel}$ for central (main) stream of the plasma tail is somewhat greater than for other streams. At the same time the induction of magnetic field for main stream is less than for other streams. This lets us suppose that the magnetic field is weak in the central part of the plasma tail and that it is increasing to the border of plasma tail. This conclusion was first made in [2].

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