THE MAGNETIC FIELD OF THE PLASMA TAIL OF COMET 1P/HALLEY

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The photometric scans of the plasma tail of Comet Halley from four observation series are compared with the profiles of brightness distribution along the tail streams which were 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 Halley as well as the coefficients of diffusion are estimated. A probable connection between cometary magnetic field changes and cometary tail structure ones are discussed.

OBSERVATIONS AND PHOTOMETRIC TREATMENT

We deal with the images of Comet Halley, which were obtained in the framework of the international program of observations of Large Scale Phenomena in December 1985. We chose two plates obtained on December 9.6618 and 9.7361, 1985 in the prime focus of the 2.6-m telescope by L. G. Akhverdian in Byurakan (Armenia). We took three plates obtained on December 12.647, 16.634, and 17.624, 1985 by K. I. Churyumov with the 1-m Zeiss RCC-telescope in Assy (Kazakhstan). We also used the plate derived on December 9.613, 1985 by S. I. Gerasimenko on the 40-cm telescope DShA in Gissar (Tadzhikistan). The plates from Byurakan were scanned with the PDS digitizer by L. G. Akhverdian and Yu. V. Sizonenko. The photometry of the plates from Assy were performed at the MAO NASU with the ATsMF-XY digitizer by K. I. Churyumov and V. G. Parusimov. Recently, the plate from Gissar was scanned by V. L. Kostiuchenko with the same digitizer. Table 1 gives the log of observations as well as the scale of the plates and the length of the scanned tails in kilometres.

Table 1. The log of observations

Plate	UT, Dec. 1985	ΔT, min	$\alpha_{1985.0}$	$\delta_{1985.0}$	Scale, $''$/mm	l, 10^6 km
DShA-135	9.61304	60	23^h32^m	$+7°08'$	103.1	1.065
ZTA-10	9.66180	40	23^h31^m	$+7°05'$	29.0	1.318
ZTA-12	9.73611	40	23^h31^m	$+7°02'$	29.0	1.318
RCC-03	12.67405	25	23^h19^m	$+5°09'$	15.5	0.343
RCC-06	16.63422	25	23^h06^m	$+2°58'$	15.5	0.529
RCC-11	17.62409	25	23^h04^m	$+2°29'$	15.5	0.541

These diverse photometric data were unified with our procedure for the photometric reduction. This procedure let us eliminate the regular photometric errors of the telescopes as well as the difference into the atmospheric extinction. We calibrated the plates with standard stars from a photometric catalogue. The photometric treatment of the comet images was completed with the drawing of the brightness distribution maps. One can see the sample of that map in Fig. 1.

CALCULATION OF BRIGHTNESS PROFILES

We derived the photometric scans along the streams in cometary tail from the brightness distribution maps. The dashed lines in Fig. 1 show the directions of these scans for December 9.6618, 1985. The obtained scans were compared with the brightness distribution profiles calculated with the diffusion model of plasma tail [4].

The model is well-known and was used to study the plasma tails of several comets. Therefore, we do not describe the model in details. It is desirable to note some improvements which we propose in the paper.

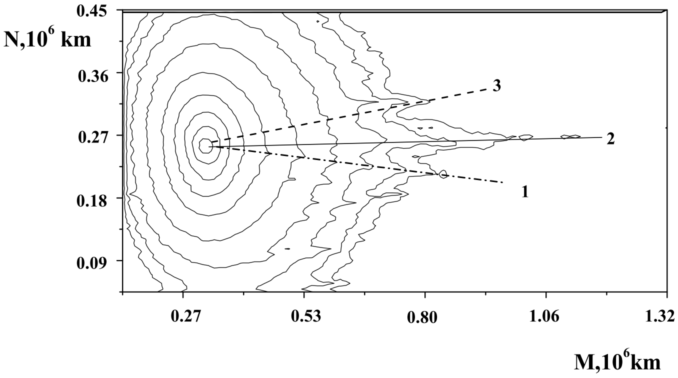

Figure 1. Isophotes of the tail of Comet Halley on December 9.6618, 1985. The dashed lines show the directions of photometric scans along the streams

The estimate for the induction magnetic field is:

$$B = 2 \cdot 10^{11} \frac{T_i}{D_{\|}(\mu)} \frac{L_{\|}}{L_{\perp} \cos\beta}, \tag{1}$$

where T_i is the temperature of comet ions and the effective acceleration of ions. The values of T_i and μ in (1) are not defined and, therefore, the estimate of B can not be low or high, it is quite uncertain. We propose to find the value of the measure of the motions of clouds in the cometary tail. With the method from [1], we estimated ion's acceleration for December 14–15 as $\mu = 97 \pm 11$. The estimate of the temperature of comet ions in [2] is not correct. We took the estimate from [5]: $T_i = (2 \div 8) \cdot 10^4$ K.

Figure 2 shows the results of comparison of the photometric scans along the main streams in plasma tail with the brightness distribution profiles calculated in the framework of diffusion model.

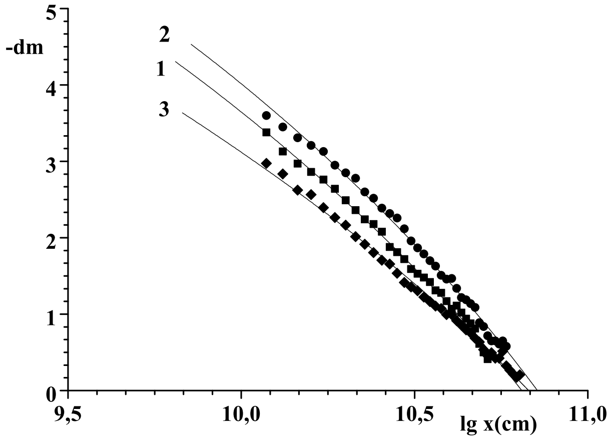

Figure 2. The comparison of the photometric scans along the main streams of tail and the calculated profiles for the plate ZTA-10 on December 9.6618, 1985. The numbers near the curves correspond to the numbers of the streams in Fig. 1

Figure 3 illustrates the comparison results for the tangential scans of the main stream of plasma tail on the plate ZTA-10.

RESULTS

We derived the sets of model parameters for all developed plates 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 2 gives sets of model parameters calculated as the mean values of the parameters for some streams of the tail. We used these parameters for calculation of physical characteristics of the plasma tail of Comet Halley with the formulas from [2]. The acceleration a and lifetime τ of comet ions, coefficients of longitudinal diffusion $D_{\|}$ and transversal diffusion $D_{\perp}$, and induction of magnetic field B for the plasma tail of Comet Halley are given in Table 3.

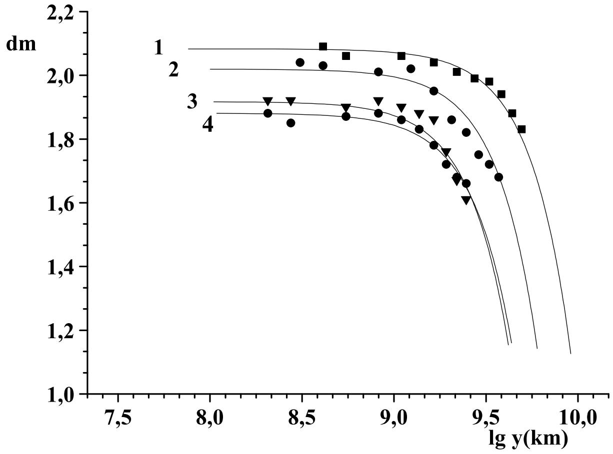

Figure 3. The comparison of the tangential photometric scans of the stream 2 of tail and the calculated profiles for the plate ZTA-10 on December 9.6618, 1985: (1) tangential scan of the stream at a distance of $3.77 \cdot 10^{10}$ cm from the nucleus, (2) at a distance of $4.45 \cdot 10^{10}$ cm, (3) at a distance of $5.82 \cdot 10^{10}$ cm, (4) at a distance of $6.49 \cdot 10^{10}$ cm

Table 2. The parameters of diffusion model for the tail of Comet Halley

Plate	Γ	$L_{\parallel}$, 10^{10} cm	$L_{\perp}$, 10^{9} cm
DShA-135	4.19±0.22	0.77±0.41	6.99±049
ZTA-10	1.32±0.34	0.68±0.02	5.38±0.42
ZTA-12	0.58±0.11	1.08±0.14	4.53±0.32
RCC-03	0.64±0.12	0.31±0.01	1.55±0.08
RCC-06	1.03±0.14	0.61±0.46	3.79±0.07
RCC-11	44.8±5.9	1.24±0.08	8.12±0.14

Table 3. Physical characteristics of the plasma tail of Comet Halley

Plate	a, cm s^{-2}	τ, 10^4 s	$D_{\parallel}$, 10^{16} cm^2 s^{-1}	$D_{\perp}$, 10^{15} cm^2 s^{-1}	B^{min}, nT	B^{max}, nT
DShA-135	31.7	6.06	0.41	0.20	8.4	33.6
ZTA-10	31.7	3.23	0.75	0.22	5.0	19.8
ZTA-12	31.7	2.70	0.48	0.19	1.4	5.8
RCC-03	33.9	1.41	0.60	0.42	9.1	36.3
RCC-06	37.3	2.33	1.02	0.15	4.1	16.2
RCC-11	38.3	21.38	0.41	0.07	1.7	6.8

Through the periods from ZTA-10 to ZTA-12 and from RCC-8506 to RCC-8511, the induction of magnetic field and coefficient of longitudinal diffusion decreased considerably. The observers [3] noted that the structure of cometary tail had changed. Many new rays and streams in plasma tail appeared. This may connect these phenomena of the magnetic field and tail of Comet Halley with DE-event, which began on December 13, 1985.

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