Dust Tail Modelling for Comet Hale-Bopp

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The results of dynamic modelling of the dust tail formation of comet C/1995 O1 (Hale-Bopp) are presented. To simulate the dust tail the trajectories of 2×106 dust particles were traced. Their sizes, ejection moments, outflow directions and velocities were defined by a Monte Carlo algorithm. The obtained three-dimensional modelled tail was projected on the sky plane to compare with the observed images.

Introduction

Comet Hale-Bopp was discovered by Alan Hale and Thomas Bopp on July 23, 1995. The huge brightness of the comet was a reason for its discovery at 7 AU from the Earth and a long term monitoring of the dust activity after perihelion passaging up today. It is undoubtedly the most studied long period comet in the Solar system. Comet Hale-Bopp dust tail shows a system of narrow, nearly rectilinear bands due to the dust fragmentation [2]. The Comet's dust activity and outgassing was not spread uniformly over its nucleus, but came largely from several large jets. Just observations of the jets allowed astronomers to measure the rotation period of the comet, which was found to be about 11 hours 46 minutes. In this study we examine dust tail of comet Hale-Bopp using dynamical simulation.

The Modelling

Modelling is carried out on the basis of acceptance of some physical, chemical and dynamic properties of the dust particles. A Monte Carlo model, originally developed by Korsun [1] for interpretation of distant comet tails, was used. Here, it was adapted for the distances closer to the Sun and new physical processes occurred in cometary tails, such as fragmentation of the moving dust particles, were added as well. To simulate the dust tail, the trajectories of each individual particle, controlled by the solar gravitation and light pressure forces, are traced. The system of the differential equations is solved to obtain the coordinates of the particles at the moment of the observation. The probability values of the initial coordinates, outflow directions and velocities, sizes and ejection moments of the individual particles, needed to solve the system, were determined using a Monte Carlo method. In this study we simulate an isotropic escape of the matter from the nucleus and consider exponential size distribution of the dust particles. The obtained cometocentric coordinates of the particles are projected on the sky plane. The simulated tail was compared with the images of the tail of the comet, provided by Dr. Herman Mikuz, Crni Vrh Observatory, Slovenia. The images were

Table 1: Model parameters of the dust particles

Parameters:	Image 1997 02 08	Image 1997 02 18	Image 1997 03 07
Age of particles, days	56	66	69
Range of radii, m^{-6}	0.3 – 8.0	0.3 – 8.0	0.3 – 7.0
Size distribution, $radius^x$	-3.6	-3.6	-3.7
Vdust, m/sec	168 – 721	143 – 640	155 – 650
Degree of fragmentation	0.1	0.1	0.2

obtained through a dust continuum filter centered at 647 nm (FWHM = 10 nm). The best model parameters and a set of the modelled isophotes are the result of our investigations. The set of the modelled isophotes are displayed on the figures below and the model parameters are listed in Table 1.

Conclusions

1. We successfully fitted the brightness distribution in the comet Hale-Bopp tail for three different dates with the model parameters similar by values.
2. The velocities of ejected dust are found to be higher than the typical values for majority of the known comets, as it was also pointed out by other researchers.
3. In order to explain the distribution of matter in the tail of the comet, the processes of dust fragmentation should be taken into account.

Acknowledgement

We thank Dr. Herman Mikuz (Crni Vrh Observatory, Slovenia) for providing his observational results for the interpretation.

References

[1] Korsun P.P. Kinematika i Fizika Nebesnykh Tel, V. 5, pp. 465-471 (2005)

[2] Pittichova J., Sekanina Z., Birkle K., et al. Earth, Moon, and Planets, V. 78, pp. 329-338 (1997)

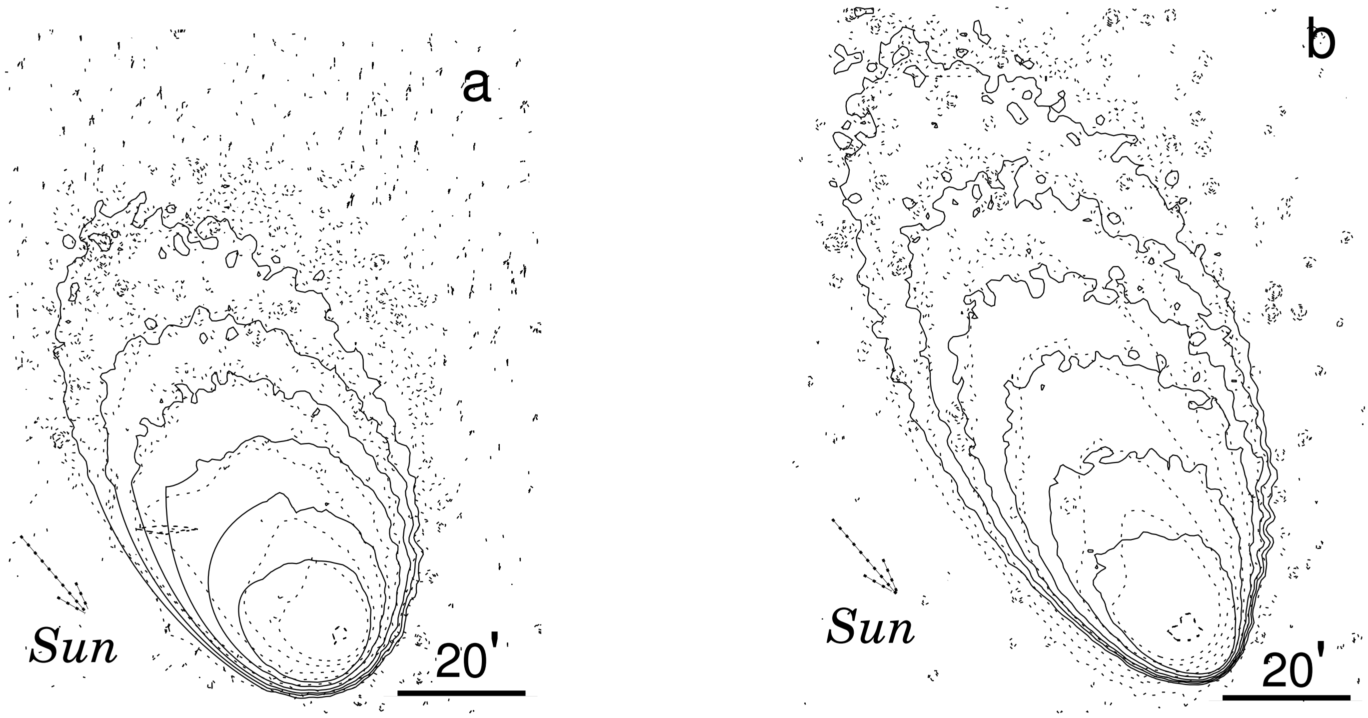

Figure 1: The best modelled (solid lines) and observed (dashed lines) isophotes for comet Hale-Bopp obtained on 08 February 1997(a) and on 18 February 1997 (b). North is to the top and East is to the right. Sunward direction is marked.

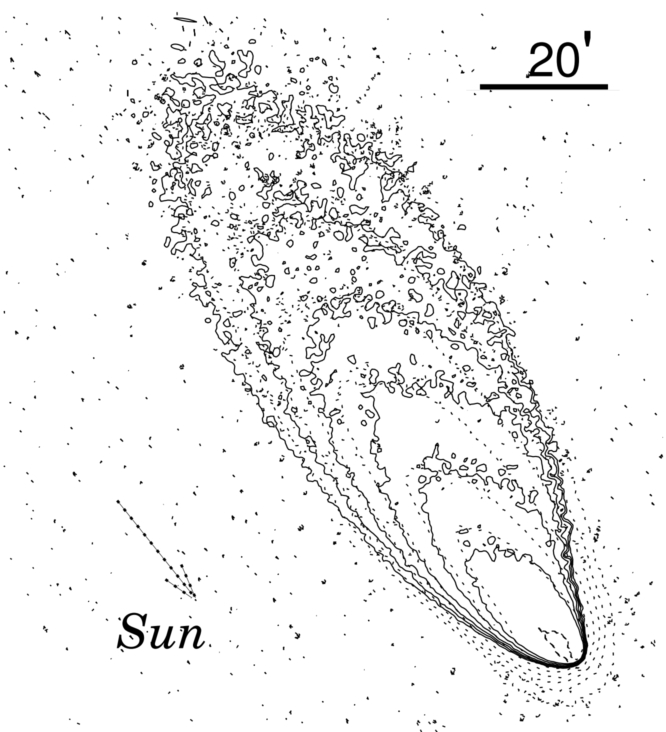

Figure 2: The best modelled (solid lines) and observed (dashed lines) isophotes for comet Hale-Bopp obtained on 07 March 1997. North is to the top and East is to the right. Sunward direction is marked.