MODELING OF COMETARY DUST TRAILS

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Introduction: The aim of this work is to present the 'Dust Trail kit' model describing the evolution of cometary dust trails. Besides the model description, as a case study, we demonstrate our analysis of the physical and spatial characteristics of the dust trail produced by the 2007 explosion of comet 17P/Holmes. Comet 17P/Holmes experienced a big outburst on 2007 October 23-24 leading to a large amount of dust particles and gas ejecting from the comet [1]. The dust particles started orbiting the Sun in different elliptic orbits. Solar radiation pressure and Jupiter's gravitational disturbance cause the particles' orbits to differ from the orbit implied by the pure gravitational model. The dust particles converge in two common nodes of their orbits making it possible, in addition to the modeling, to directly observe the dust in the visible light spectrum using ground-based telescopes [6]. One of the aims of our work is to study the populations of different sized particles ejected during the 2007 outburst [2] from the coma of 17P/Holmes by developing and applying the dust trail particle model.

Methods: The dust trail particle model comprises multiparticle Monte Carlo modeling including the solar radiation pressure effects, gravitational disturbance caused by Jupiter, and also gravitational interaction of the dust particles with the parent comet itself. The model is validated using the observational data obtained by us [3] [4] [5]. The obtained results allow us to make predictions for the future dust trail behavior when it comes close to the 2007 explosion point. According to the earlier proposal, the particle size is modeled using the β parameter, which generates non-gravitational solar radiation pressure disturbance to the particle [6]. Ejection speed was different for the different sized particles [7]. Smaller particles attained greater maximum speed than larger particles.

Results: We have observed dust particles in the trail of comet 17P/Holmes starting from 2013 February until 2015 October in the southern common node and in the northern common node close to the year 2007 explosion point [3] [4] [5]. We have developed the model describing the evolution of cometary dust trails and have successfully used these observations to validate the modeling accuracy using the prominent example of comet 17P/Holmes. We have made predictions of future observability of dust particles near the comet's 17P/Holmes explosion point in the Northern Hemisphere.

Conclusions: Our modeling and its comparison to the observations show that the developed model describes well the evolution of cometary dust trails. By applying the model to the dust trail of comet 17P/Holmes we observe the following. The trail will be visible in 2021 and 2022 even by using modest aperture telescopic systems, but may require image subtraction to enhance particle detectability. The surface brightness of the dust trail in 2021-2022 will be similar or greater to that of 2013-2014 in the southern node of the orbit in the Southern Hemisphere, but will be less than it was observed in February 2015 near the explosion point in the Northern Hemisphere. This kind of interplanetary dust is likely to be observable also using mid infrared spectroscopy.

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Dedication: This presentation is dedicated to the memory of mastermind Esko Lyytinen who did a tremendous amount of original research, modeling, and predictions of meteor streams for the scientific community.

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