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Is it possible to observe meteoroids from Asteroid (3200) Phaethon ejected in 2009?

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In 2009, Asteroid (3200) Phaethon has shown a short unexpected brightening, which could be interpreted as the ejection of dust particles. A numerical model was constructed to find out whether the dust swarm could have been observed from the Earth.[1]

1 Introduction

In June 2009, the parent body of the Geminids, Asteroid (3200) Phaeton, at that time close to its perihelion, has shown a short, unexpected brightening, which can be interpreted as the ejection of dust particles (Jewitt and Li, 2010). To study the possibility that the produced hypothetical dust cloud could be observed in the ensuing decade, we examined a numerical model of this cloud or, in other words, a meteoroid swarm. The method of modeling was quite standard: ejection of meteoroids from the asteroid was simulated, and their orbits were numerically integrated till 2021 January 20.0. In the process, we followed up the close encounters of meteoroids with the Earth and calculated the theoretical radiants for such meteoroids. We endeavored to answer the following answers:

1. could the dust produced in 2009 be observed on the Earth as meteors; and
2. if so, could the meteor activity produced by this dust stream stand out against the regular Geminid activity?

2 What was found

The first close approach of the model swarm to the Earth was in 2014, then in 2017, 2018, and 2020. In 2017 (the year when Phaethon should approach the Earth at the distance of about 0.0689 AU) the model meteor shower was several times more abundant than in the other years. All other approach circumstances (maximum of activity, radiant area) were identical.

The outburst in Geminid activity due to this swarm may take place at solar longitude $\lambda_\odot = 262^{\circ}\!.5$, i.e., after the main Geminid maximum. To exceed the usual level of activity, the mass of the 2009 swarm should exceed approximately 2×10^8 kg. The mass of the dust ejected from Phaethon should be somewhat larger. The upper limit of dust production by Phaethon due to thermal fracture is estimated to be around 10^{10} kg (Jewitt and Li, 2010), so it is possible.

The radiation area of the model outburst meteors is a small spot with geocentric equatorial coordinates $\alpha \approx 114^{\circ}\!.65 \pm 2^{\circ}\!.5$ and $\delta \approx +32^{\circ}\!.7 \pm 0^{\circ}\!.1$. A concentration of radiants of meteors of various magnitudes in this spot is a feature that allows to distinguish the outburst. The lack of observational data to study the fine structure of the Geminid radiants is a problem to solve in future. The observational bias also calls for further investigations.

The minimal distance between the model particles and the Earth was never inferior to 0.018 AU for all approaches under consideration between the model swarm and the Earth. Taking into account that the radius of the Earth's influence sphere is about 0.03 AU, it is possible in principle to observe the resulting meteors, but the probability of the event is not high.

It was found, however, that the distance between the model swarm and the Earth slowly decreases with time. Therefore, it was decided to continue the integrations till the year 2050, when the next calculated close approach of Phaethon and the Earth takes place (the minimal distance then being 0.0826 AU, at JD 2470152.2595). Indeed, the minimal distance between the swarm and the Earth lowers to 0.015 AU in 2050. All the approach features were the same as in 2017.

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[1]The full version of this paper was published in the *Monthly Notices of the Royal Astronomical Society* (Ryabova, 2012).