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Comet population near Mars and predicted meteoroid encounters with Phobos

V. Dmitriev (1), V. Lupovka (1), V. Sizenkov (1), J. Oberst (1,2,3)
(1) State University of Geodesy and Cartography (MIIGAiK), Gorokhovskiy per., 4, 105064, Moscow, Russia (v.lupovka@miigaik.ru, v_dmitriev@mexlab.ru); (2) Technical University of Berlin, Berlin, Germany; (3) German Aerospace Centre (DLR), Berlin, Germany

Abstract

A comet database was analyzed for selecting potential parent bodies of Martian meteoroid streams. A spatial model of meteoroid distributions in the stream tube was constructed by using parameters of meteoroid streams observable from the Earth which were extrapolated to Mars. The radiants and activity time of potential Martian meteoroid streams were determined. The obtained model allows estimating probability and velocity of possible meteoroid encounters with Mars and the Martian satellites.

1. Introduction

Meteoroid streams are the results of comet degradation which form during comet approaches to the Sun. While meteoroid streams approaching Earth are well-known to astronomers, nearly nothing is known about the meteoroid environment near other planets, notably Mars.

Modeling of Martian meteoroid environment requires several work steps: identify potential parent bodies of Martian meteoroid streams – comets that have orbits approaching to the Mars orbit; construct models of potential meteoroid streams; determine their radiants and activity time; estimate the probability and velocity of possible meteoroid encounters with Mars and Martian satellites.

2. Selecting potential parent bodies of Martian meteoroid streams

A database of 1037 periodical comets [1] was analyzed for selecting potential parent bodies of Martian meteoroid streams. Coordinates and distances of the nearest approaches of comet orbits to Mars orbit were calculated for each comet from the database. We found 137 comets in orbits that approach Mars orbit within less than 0.15AU. Among them 88 comets approach Mars orbit within less than 0.1AU, and 17 comets of them approach Earth orbit within less than 0.15AU as well. The well-known comet 1P/Halley from this list is the parent body of two meteor showers: the Eta Aquariids in early May, and the Orionids in late October [1, 2].

3. The Model

Model of meteoroids distribution in the stream tube was constructed by using parameters of the Eta Aquariids and the Orionids meteoroid streams.

3.1 Preliminary propositions

The following assumptions were made for modeling:

- In the stream, the distribution of meteoroid orbits is radially symmetric relative to the stream axis (parent body orbit), and maximum of meteoroid distribution density is at the stream axis.
- In the stream tube, meteoroids have uniform distribution, i.e. meteoroid numbers do not depend on parent body position.
- Meteoroid stream radiants are determined by the parent body velocity vector at the moment of the nearest approaches to the planet orbit (i.e. Mars).
- Comet orbital elements have small perturbations, and we can neglect their changes in time for modeling.

3.2 Meteoroid distribution density as function of distance from stream axis

For modeling we use meteoroid stream parameters from [1, 2, 3]: time of maximum activity (specifically, the solar longitude when the shower or storm maximum occurs), the maximal cumulative particle flux, the profile description index, and the cumulative mass distribution.

The meteoroid cumulative particle flux of terrestrial meteoroid streams in [1, 2, 3] is presented as function of the solar longitude (i.e. as function of time). For modeling Martian meteoroid streams the cumulative particle flux (ρ) was recalculated as function of distance (r) from the stream axis (Figure 1):

$$\rho(r) = ae^{br},$$

where a – is a parameter depending on the cumulative mass distribution, and b – is a depending on specific stream structure and describing the profile description index.

In this case the comet velocity vector in the moment of the nearest approach is considered as the stream axis. Also we supposed that the moment of the nearest approach is the time of maximum activity.

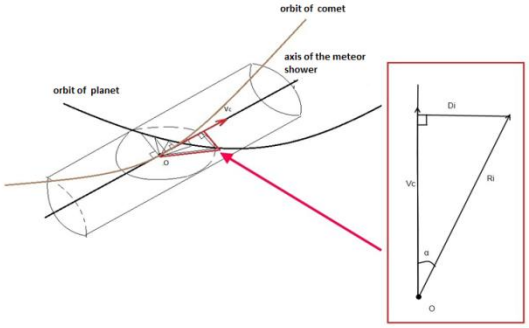

Figure 1: Geometric model for recalculating meteoroid distribution density as a function of distance from the stream axis**.**

The plots on Figure 2 show the distribution density as function of distance from the stream axis for the Eta Aquariids and the Orionids meteoroid streams. It should be noted that both streams have the same parent body comet 1P/Halley, however their distribution density functions are different.

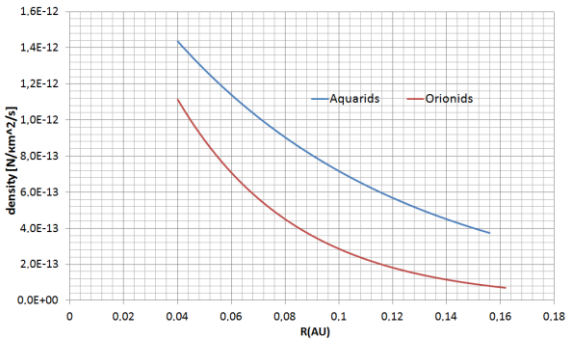

Figure 2: Distribution meteoroid density numbers for the Eta Aquariids and the Orionids meteoroid streams as function of distance from the stream axis (e.g. for 1 kg particles).

4. Summary and Conclusions

A database of 1037 periodical comets was analyzed for selecting potential parent bodies of Martian meteoroid streams. As result 137 comets were found that had orbits to approach Mars orbit within less than 0.15AU, among them 88 comets that approach Mars orbit less than 0.1AU. From this list 17 comets approach Earth orbit within less than 0.15AU as well. The time of activity of these potential Martian meteoroid streams was obtained. The model of the cumulative particle flux as function of distance from the stream axis was constructed. This model can be used for modelling of the meteoroid bombardment of Mars, Phobos and Deimos.

Acknowledgements

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