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Simulations of meteoroid impacts on Phobos and global crater distributions

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Abstract

Using a data base of 1037 periodic comets, we identified time of activity of potential Martian meteoroid streams. We derived a model of the cumulative particle flux as function of distance from the stream axis. The model allows estimating the probability and velocity of possible meteoroid encounters with Mars and the Martian satellites and was used for modelling of the current Phobos meteoroid bombardment. The results of stochastic modeling of meteoroid impacts on Phobos are presented.

1. Introduction

While meteoroid streams approaching Earth are well-known to astronomers, nearly nothing is known about foreign meteoroid environments, notably near Mars. The modeling of the Martian meteoroid flux is also useful for supporting future missions to Mars and its satellites.

Using a data base of 1037 periodic comets, we identified time of activity of potential Martian meteoroid streams We found 137 comets in orbits that approach Mars orbit within less than 0.15AU. Among them 88 comets approach Mars orbit within 0.1AU (see also companion abstract)

The model of meteoroids distribution in the stream tube was constructed by using well-known orbital parameters of the Eta Aquariids and the Orionids meteor showers. Specifically, the cumulative particle flux (ρ) was presented as function of distance r from the stream axis [4]:

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

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

This model can be used for modelling the meteoroid bombardment of Mars, Phobos and Deimos.

This paper presents results for numerical simulations of the Phobos meteoroid bombardement.

2. Stochastic modeling of meteoroid impacts on Phobos and global crater distributions

The time of activity of potential Martian meteoroid streams was obtained for each selected comet. The stochastic modelling of meteoroid impacts on Phobos and global crater distributions was performed by uniform random-event generator on a sphere [5].

Directions and velocities of possible impacts were calculated. Radiant coordinates were determined by comet velocity vectors at the moment of the nearest approach to Mars orbit. The effect of meteoroid screening by Mars and impact velocity dependence on leading or tailing Phobos hemisphere were taken into account.

As a result, we obtain the global cratering distribution (Figure 1). In the example we show impacts of 10 gram particles that would impact Phobos during 400 Martian years. The global crater distributions is shown in the Phobos centered surface-fixed coordinate system.

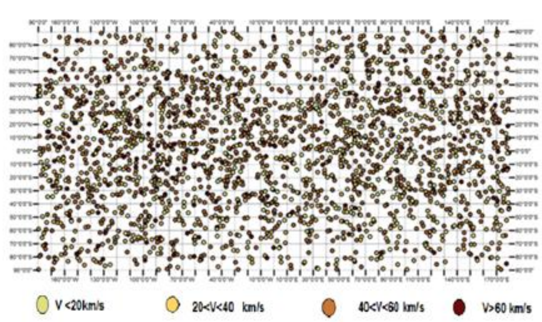

Figure 1: Stochastic model for the global crater distributions on Phobos (here: for 10 gram particles during 400 Martian years).

A deficit of impacts is observed in the area around prime meridian. This is probably the effect of meteoroid screening by Mars. In generally, screening is estimated as 11% for particles that impact on the Phobos hemisphere oriented to Mars or about 5.5% as average meteoroid number. For some specific comets the common screening effect is: 1P/Halley – 4.9%, 13P – 3.9%, 38P – 5.4%, C/1974 – 4.7%, and C/2007 D2 – 4.7%. The difference between number of impacts north and south is about 2%, for east and west hemisphere - 2% as well.

3. Particle distribution by velocity

The particle distribution by velocity relative to Phobos depends on radiant coordinates and orbital Phobos velocity. Phobos orbital motion and rotation are synchronized. As a result, velocities of particles that impact onto Phobos leading and tailing hemisphere differ by about ±2 km/s (Figure 2).

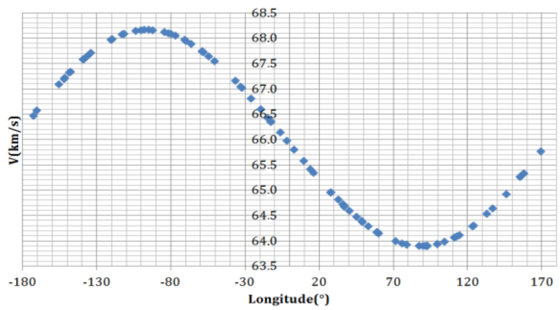

Figure 2: Dependence of impact velocity on Phobos-centric longitude for meteoroids from 1P/Halley.

Most impacts were with velocities from 30 km/s to 60 km/s. The mean impact velocity for leading hemisphere is about 39.53 km/s, and for trailing hemisphere – 37.17 km/s.

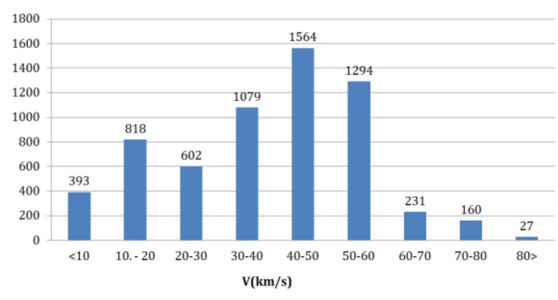

Figure 2: Particle number distribution by impact velocity (here: for 10 gram particles during 1000 Martian years).

4. Summary and Conclusions

The results of stochastic modelling of meteoroid impacts on Phobos and appropriate global crater distributions are presented. The effect of meteoroid screening by Mars is about 11% for particles that impact on the Phobos hemisphere oriented to Mars or about 5.5% in average impact numbers. Velocities of particles that impact onto Phobos' leading and trailing hemisphere are different by up to ±2 km/s.

Acknowledgements

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