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Orbital evolution of ejecta from Phobos and formation of dust rings

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Abstract

We have studied the orbital evolution of particles ejected from Phobos by meteoroid impacts. Simulations of trajectories of the particles about Mars is performed by numerical integration for a one thousand year interval. We took into account the Mars gravity field, third body attraction and solar radiation pressure. The simulations show dust ring formation for some initial conditions. The long-term stability of rings is estimated.

1. Introduction

Giant planets are known to have observable ring systems. However, it is considerable that dust rings could be formed around earth-type planets as well. Particles ejected from natural planet satellites by meteoroid impacts can be one of the sources of material for dust rings [1].

This paper presents results of numerical simulation of dust rings formation by such a way. Specifically, the possibility of dust rings formation around Mars is considered. We investigate if ejecta from Phobos by meteoroid impacts can form rings. When the impact takes place, ejected particles start practically from the same position (crater), but with different velocities and under different ejection angles. Therefore, we consider orbital evolution of a set of particles with stochastically modeled initial velocity vectors.

2. Method

Phobos is considered as the particles' parent body. According to [2] the mean Phobos soil density is 1.872 ± 0.076 g/cm^3 and geometric albedo is 0.071 ± 0.012. Initially a set of several tens of particles was generated with 0.1 gram mass, with start coordinates equal to Phobos coordinates at the epoch January 1, 2000 and stochastically modeled initial velocities around plus or minus 1 km/s .from the orbital Phobos velocity.

Particles orbit integration was performed by the explicit Adams–Bashforth method from January 1, 2000 to January 1, 3000 as described in [4]. Perturbations invoked by the Mars gravity field for up to 30x30, third body attraction (Sun, 7 planets and Moon) and solar radiation pressure (cannonball model) were taken into account. SPICE kernels and appropriate SPICE functions were used for obtaining Sun and planets ephemeris and coordinate transformations [3].

3. Results

Simulation results show that most of the generated particles are removed from the Phobos-like Mars orbit. Just 13 modeled particles with initial velocities in between -0.26 km/s to 0.13 km/s from the orbital Phobos velocity formed a ring-similar structure around Phobos orbit (Figures 1-4). Situations corresponding to 100, 400, and 800 years since ejecta epoch are shown in figures 1-3. The figures correspond to Mars equatorial plane. Final particle positions since one thousand years after ejection are shown in Figure 4.

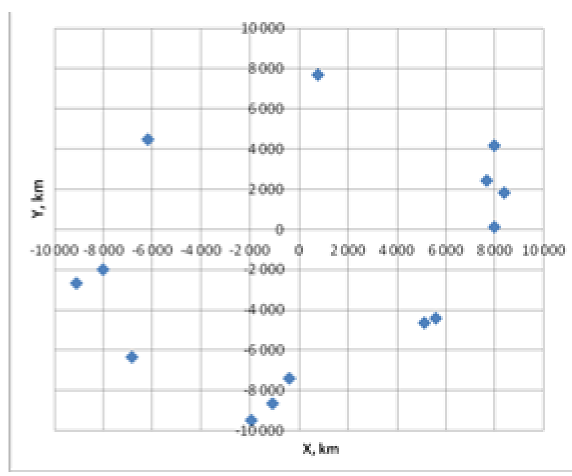

Figure 1: Particle positions at 2100.

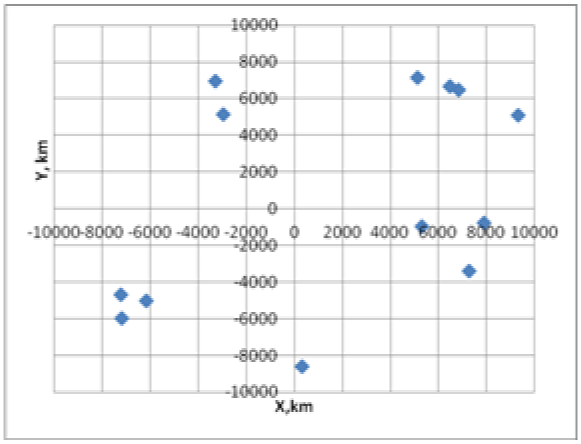

Figure 2: Particle positions at 2400.

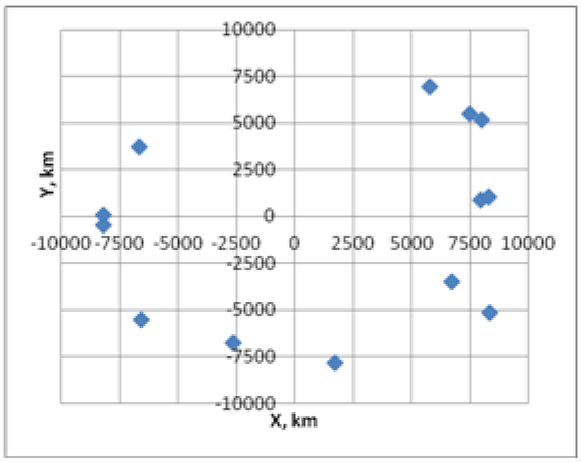

Figure 3: Particle positions at 2800.

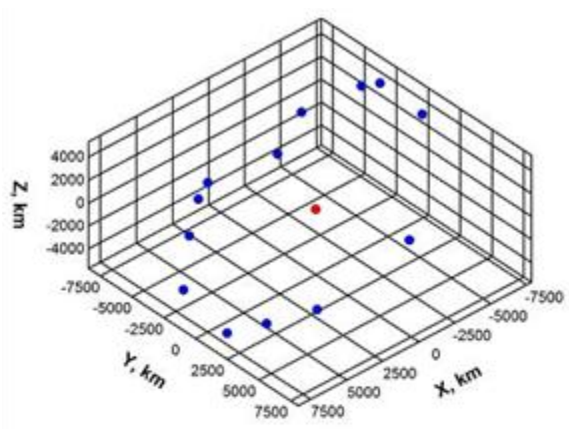

Figure 4: Final particle positions at 3000. – A ring-similar structure around Phobos orbit since one thousand year after ejection. The Mars position is marked by a red point in the center.

4. Summary and Conclusions

Results of simulation orbital evolution of ejecta from Phobos show that for some initial conditions ring-similar structure can be formed by ejected particles. According to our investigation this ring appears to have a stability for a minimum of one thousand years.

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