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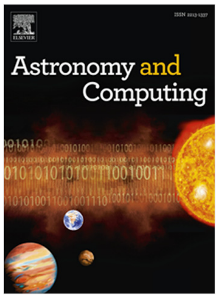

Yarkovsky effect and solar radiation pressure on the orbital dynamics of the asteroid (101955) Bennu

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Yarkovsky effect and solar radiation pressure on the orbital dynamics of the asteroid (101955) Bennu

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Abstract

In this paper, the orbital perturbation of near-Earth asteroid Bennu due to Yarkovsky effect and solar radiation pressure (SRP) is studied. The physical model of the astroid Bennu is used to compute Yarkovsky acceleration. The basic equation of motion is written in perturbed two body problem to show the variations in orbital elements and change in position of Bennu. The change in semi-major axis due to perturbation of Yarkovsky effect is obtained. In the presence of Yarkovsky effect, the semi-major axis decreases by 350m over one period. The magnitude of Yarkovsky force and solar radiation pressure force is computed. We find that the maximum magnitude of Yarkovsky force and solar radiation pressure force as 0.09N and 1.16N, respectively, at the perihelion. It is found that Yarkovsky effect shifts the position of Bennu up to 185.2km over 12 years of period. The position change of Bennu due to combined effect of Yarkovsky force and solar radiation pressure is 172.35km. This study shows that the solar radiation pressure has a much smaller effect on the orbit of Bennu than Yarkovsky effect.

Keywords: Yarkovsky effect; Perturbed two-body problem; Solar radiation pressure; Orbital elements.

1. Introduction

Bennu (101955) is a half kilometer potentially dangerous near-Earth asteroid and it is an object of great interest because the Earth impacts for Bennu are possible in the later part of next century (Milani et al., 2009). Bennu is the target of the OSIRIS-REx sample return mission(launched on 08 September 2016, to reach the asteroid in the year 2018, and return asteroid's samples to the Earth in 2023) of NASA ($https://www.nasa.gov/osiris-rex$). In the year 2135, Bennu will be in close approach to the Earth and Moon, which could potentially alter its orbit so much that there is slight chance it could impact with the Earth later in that century. The non-gravitational forces should be considered as important as collisions and gravitational perturbations for the overall understanding of the asteroid evolution (Bottke et al., 2006). The solar radiation pressure and Yarkovsky effect are non-gravitational perturbations which are considered when predicting a change in an asteroid's orbit. Yarkovsky effect (Bottke et al., 2006) is the most significant non-gravitational perturbation that perturbs the orbits of small bodies of the solar system including the near-Earth asteroids(NEAs). This small force is driven by thermal properties of an asteroid as well as the amount of absorbed radiation. The heat thruster is produced when small bodies orbiting the Sun absorb solar energy, heats up, and radiates it back into space as thermal energy after a short delay, due to thermal inertia of asteroid. This thermal emission, while tiny produces a force that can lead a secular change in the objects semi-major axis and other orbital elements, causing objects to spiral inward or outward at different rates as a function of their spin, orbit and physical and thermal properties of the objects. The resultant force has two components, one radially outward the Sun and the other in the direction of the orbit, causing prograde rotating asteroids to spiral outward. A body with a retrograde rotation will feel an acceleration with one component anti-aligned with its velocity, causing asteroids to spiral inwards. Yarkovsky force primarily cause secular variation in semi-major axis of the orbit. Larger asteroids experience less Yarkovsky force than the smaller one because the amount of absorbed radiation increases with the square of the radius

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