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Deflect an hazardous asteroid through Kinetic Impact: Aplication in 101955 Bennu

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Abstract

The present work aims to study the use of a kinetic impact technique as a way to deflect asteroids that may present some risk of collision with the Earth at a given time. This is a very current topic of research and it is related to planetary defense. It has been receiving the attention of researchers worldwide. In the work to be developed here, intend to evaluate in more detail the possibility of deflecting the orbit of asteroid 101955 Bennu, taking into account specific aspects.

Asteroids are the smallest bodies in the solar system, usually with diameters on the order of a few hundred's, or even only tens of kilometers. The total mass of all asteroids in the solar system must be less than the mass of the Earth's Moon. Despite this fact, they are objects of great importance. They must contain information about the formation of the solar system, since its chemical and physical compositions remain practically constant over time. These bodies also pose a danger to Earth, as many of these bodies are on a trajectory that passes close to Earth. There is also the possibility of mining on asteroids, in order to extract precious metals and other natural resources.

Asteroids have a very irregular shape, which makes their study difficult. In addition, they have rotational movement, in general very complex, due to their irregular shape. Asteroids are classified into groups: NEA (Near-Earth Asteroid), Trojans, Kuiper Belt, etc. NEAs are the most dangerous from the point of view of collision with Earth, since their trajectories are close to Earth's orbit. There is even a mission, AIDA (Asteroid Impact and Deflection Assessment), in which ESA aims to achieve a binary system (65803 Didymos). There is also the American Asteroid Redirect Mission (ARM), which plans to collected item over a long period of time to deflect the asteroid's orbit. Within this context, the present work intends to focus on the application aimed at the deflection an asteroid on a hazardous course with Earth, utilizing the technique of kinetic impact.

For this project we are using the numerical integrator package Mercury N-bodies, designed to simulate the orbit of bodies of different sizes around a central body. The different numerical integrators present in Mercury allow the user to obtain a good relationship between the computational cost and the resolution of the simulations. Mercury also allows the user to add forces from sources other than gravity, as well as to modify algorithms such as collisions that, by default, result in the perfect fusion of two bodies with mass conservations and linear momentum.

For the input data for integration, the components of position and velocity of the bodies were used, taken from the JPL Horizons website, for the same date used in this work. The mass of (7,329 ±

0.009) × 10^{10}kg and density of 1190 ± 13 kg.m^{-3} were considered for the asteroid Bennu (Kováčová et al.2020, Lauretta et al.2019a, Scheeres et al. 2019). We are not considering the composition and dimensions of the asteroid, as well as its rotation properties and minor disturbances that may occur due to its non-linear dynamics.

For this work, we used velocity variations simulating an impact opposite to the direction of the asteroid's movement (Δv negative) and also in the same direction of movement of the asteroid (Δv positive). The variations used here were from 10 mm/s to 50 mm/s. We also divided the impact point into 16 parts of the asteroid's orbital period, approximately 27 days to achieve greater precision in the results and also to reach the perihelion and aphelion points.

We are also monitoring the influence of all planets in the solar system, applying the technique of deflecting the asteroid considering all the planets of the solar system, a system of 4 bodies (Sun, Earth, Moon and asteroid) and a system of 5 bodies (Sun, Earth, Moon, Jupiter and asteroid), to determine Jupiter's influence on the results.

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