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POTENTIALLY HAZARDOUS ASTEROID IMPACT MITIGATION STRATEGY USING TETHERS

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ABSTRACT

One of the major problems related to asteroids nowadays is the risk of collision with the Earth. Although the probability of impact is low, the consequences of a collision of this type could cause irreversible consequences, inspiring several groups around the world to study this problem. This paper presents studies related to a technique that uses a smaller asteroid to help the deflection of a larger one. A space tether is used to connect the asteroids, consequently altering the center of mass of the Potentially Hazardous Asteroid (PHA). One of the main advantages of this technique is that it does not generate fragments, which could become a bigger problem.

The dynamics for the PHA-tether-asteroid system is developed, and several simulations are obtained for different initial conditions. The motion is assumed to be planar, using the orbital plane of the PHA around the Sun. The PHA is modelled as an irregularly shaped body, while the smaller asteroid is considered to be a point mass. The smaller asteroid is connected to the PHA by a rigid, massless and inextensible tether. In this work, the effect on the deviations due to the variation of

the angle between the two asteroids is studied, thus the pendulum motion of the tether is taken into account.

Asteroid Bennu (1999 RQ36) is chosen for the numerical simulations. Bennu is a PHA, part of the Apollo group of NEAs. It has a mean diameter of approximately 492 meters, rotation period of 4.3 hours, mass of 7.8×10^{10} kg, and orbital period of 1.2 years. Bennu makes a close approach to Earth every 6 years, and it orbits the Sun nearly in the same plane as Earth. The results were obtained varying the four main parameters, which are: tether length, mass ratio, orbital position for the tether attachment (perihelion and aphelion), and the angle and angular velocity of the tether at the time of its attachment to the surface of the PHA. Bennu and the Earth are positioned in the perihelion of their orbits to begin the simulation. The Earth's gravitational influence is not considered in this model. The angle between the line of apsides of the two bodies has a high influence on the determination of the Earth-Bennu distance.

The strategy can also be used to approximate the PHA from the Earth in space exploration missions. The results show that the rotation of the PHA is modified depending on the configuration of the tether attachment to the small asteroid. It was also observed that attaching the tether at the perihelion of Bennu's orbit increases the deviation when comparing the orbit with and without the tether.

Therefore, it is possible to obtain deviations that are good enough to avoid a collision, depending on the configuration of the system and the warning time. This indicates that the proposed method is feasible for planetary defense.