Deflection of potentially dangerous asteroids using the deflection technique by kinetic impact and gravitational perturbations

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Abstract. Within the work to be developed here, we intend to evaluate in more detail the possibility of deflecting the orbit of the asteroid 101955 Bennu by applying variations in its velocity, simulating the kinetic impact technique, at different positions throughout its orbital period and measuring the effects of close encounters with planet Earth. We will see that, over a relatively long period of time (100 years), the asteroid has several close encounters with the planet. We also address the kinetic impact deflection technique in a scenario where we have a short time to deflect an asteroid that will collide with Earth. For this, we also used a maneuver similar to a powered gravity-assist maneuver with Earth in a pre-impact pass to alter the trajectory of the asteroid to avoid collision.

Keywords: Asteroid deflect · planetary defense · gravitational perturbation.

1 Results

For the case of the asteroid Bennu, we have that, along time, the asteroid has several close encounters with Earth. When we apply impulses, we can change these close encounters, so changing the energy of the asteroid. Therefore, we can change the orbit of the asteroid with a small impulse initially and the gravitational perturbation becomes the responsible to make most of changes in the trajectory of the asteroid. More information can be found in [1]. Figure 1, shows that the asteroid Bennu changed its velocity by -20 mm/s between 70 and 80 years after the impulse.

For the case of the asteroid that will have a collision with Earth, we forced the asteroid to have a close encounter with Earth and after two years, it returns and collide with Earth. We are considering a three body problem in this case, were we are using the Sun, Earth and an asteroid. We apply velocity variations before the first close encounter, during the close encounter and after the close encounter. Some results are found in Figure 2. More information can be found in [2].

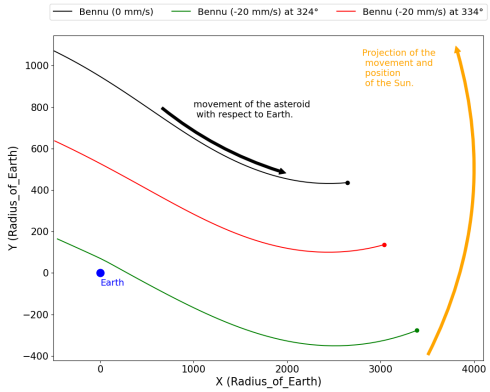

Fig. 1. Close approach between the asteroid Bennu and Earth between 70 and 80 years after the impulse. We have the impulses applied in two different positions (Mean anomalies of 324° and 334°).

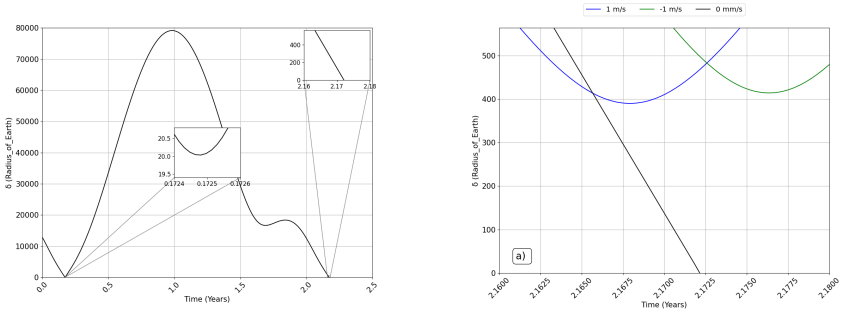

Fig. 2. The figure on the left shows the trajectory of the asteroid. The figure on the right shows the deviation from the trajectory at the moment the collision would occur.

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References

1. Chagas, B. S., Prado, A. F. B. A., and Winter, O. C. (2022). Gravitational Perturbations Correlated With The Asteroid Kinetic Impact Deflection Technique.
2. Chagas, B. S., Prado, A. F. B. D. A., and Winter, O. C. (2022). Deflecting an Asteroid on a Collision Course with Earth Using a Powered Swing-By Maneuver. Symmetry, 14(8), 1658.