Deflect an hazardous asteroid through Kinetic Impact and analyse the influence of the ‘swing by’ maneuver

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INTRODUCTION AND OBJECTIVES

- Asteroids are the smallest bodies in the solar system.
- The total mass of all asteroids in the solar system must be less than the mass of the Earth’s Moon.
- 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.
- Within this context, the present work intends to focus on the application aimed at the deflect an hazardous asteroid through kinetic impact.
- The asteroid’s orbit behavior will be analyzed to determine the accuracy of the technique and the influence of ‘swing by’ maneuver.
- To do this, we will be measure the deviation and displacement obtained at the point of maximum approximation between the body and the Earth.

METHODOLOGY

- To simulation the impact kinetic in asteroid, we do variations in its velocity in it’s initially conditions.
- For the input data for integration, the keplerian elements of the bodies, were obtained from the JPL Horizons website.
- The asteroid choice was 99942 Apophis due its approximation on year of 2029.
- The velocity variations choice were - 50 mm/s, -30 mm/s, -10 mm/s, 10 mm/s, 30 mm/s, 50 mm/s.
- The Rebound integrator package was used.
- Was assumed the system contain all planets in Solar System.
- The period choised was between 2029/04/20 - 2039/04/21 (After its approximation in 2029).
- The Figure 1 shows the approximations of asteroid with the Earth on year of 2036, before and after the velocity variations.

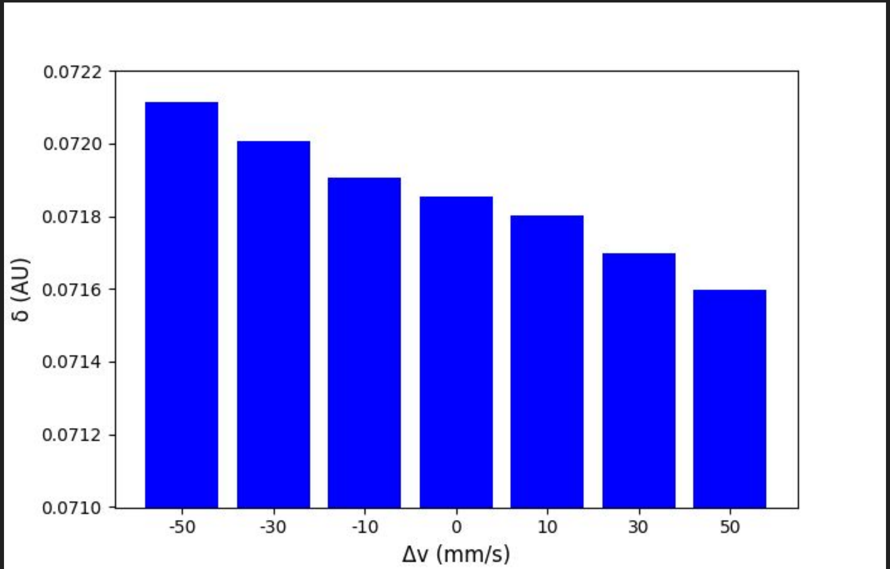

Figure 1- The figure show the approximations of asteroid with Earth on year of 2036. We can look that the variations assumed, it could cause variations in approximation. The negative variations in velocity were more efficient in to put away the asteroid while the positive variations brought the asteroid a little closer. This result is in agreement with works in the literature and exciting us for we can variation the approximations same with the lower variations in velocity, as for example, -10 mm/s for to put away the asteroid or 10 mm/s to brought a little closer it Earth.

- The Figure 2 show us the semi major axis and eccentricity of asteroid and the Earth.
- We can look that the velocity variations don’t cause strroungly perturbations in this elements.
- The Figure 3 show the behavior of approximations between the asteroid Apophis and Earth (Top Figure), and the energy of system asteroid-Earth in the same period (Down Figure).
- In Figure 3 (Top), we can look that the variations in approximations occur in 2036 (enlarged region), that was our target.
- In Figure 3 (down), we can look that the energy has small peaks in some approximations of asteroid with Earth, culminating in a biggest peak on year of 2036.
- The dashed lines, represent the regions that occur the peaks and its relationship with the approximations between the bodies.

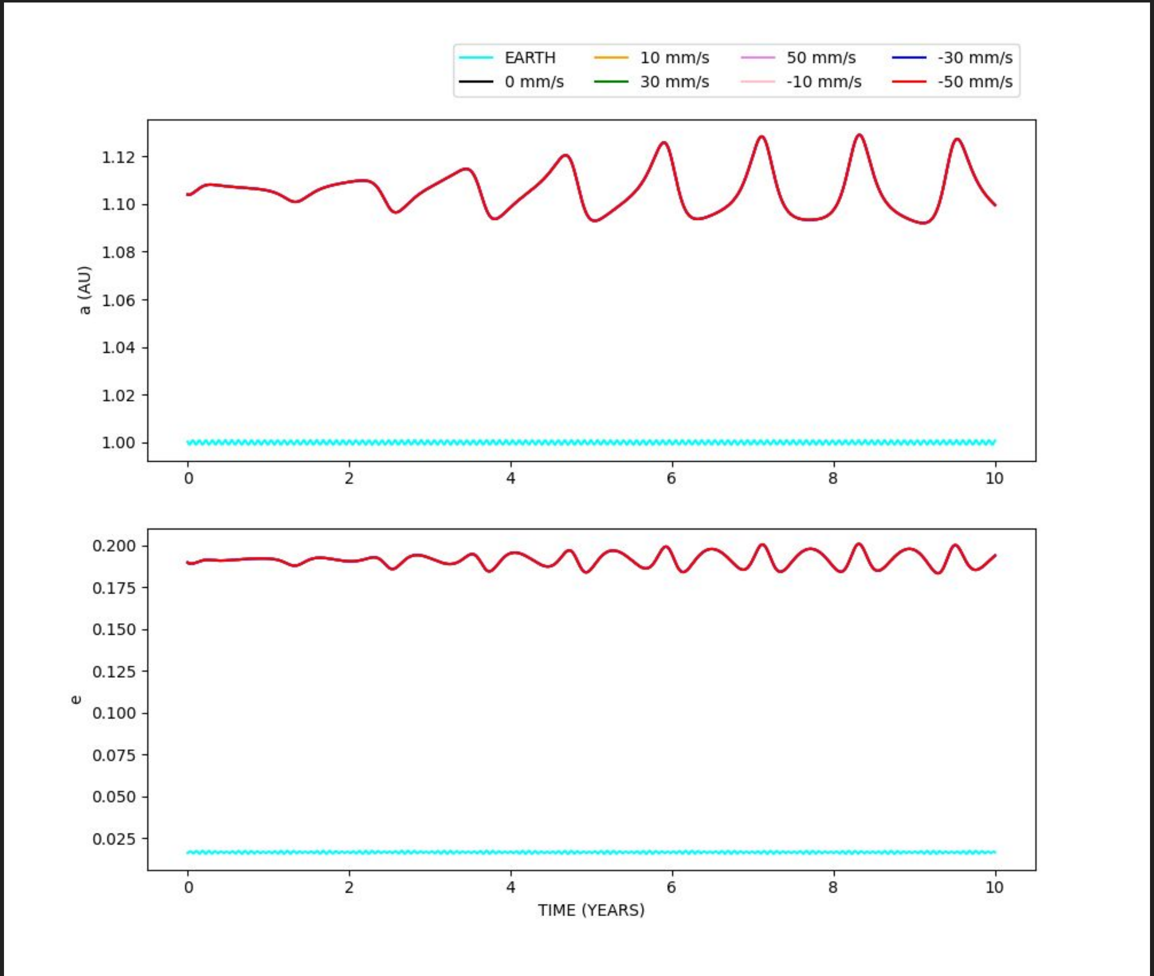

Figure 2 - The semi-major-axis (Top) and eccentricity (Down) in the period of 10 years. Like we can look, the velocity variations don't cause significant perturbations in behavior of this elements. Looking to the Figure, we can observed that the semi-major-axis and eccentricity of Earth don't cause perturbations in significant in semi-major-axis and eccentricity of asteroid Apophis. That gived us confidence to continue building our model the way we are doing.

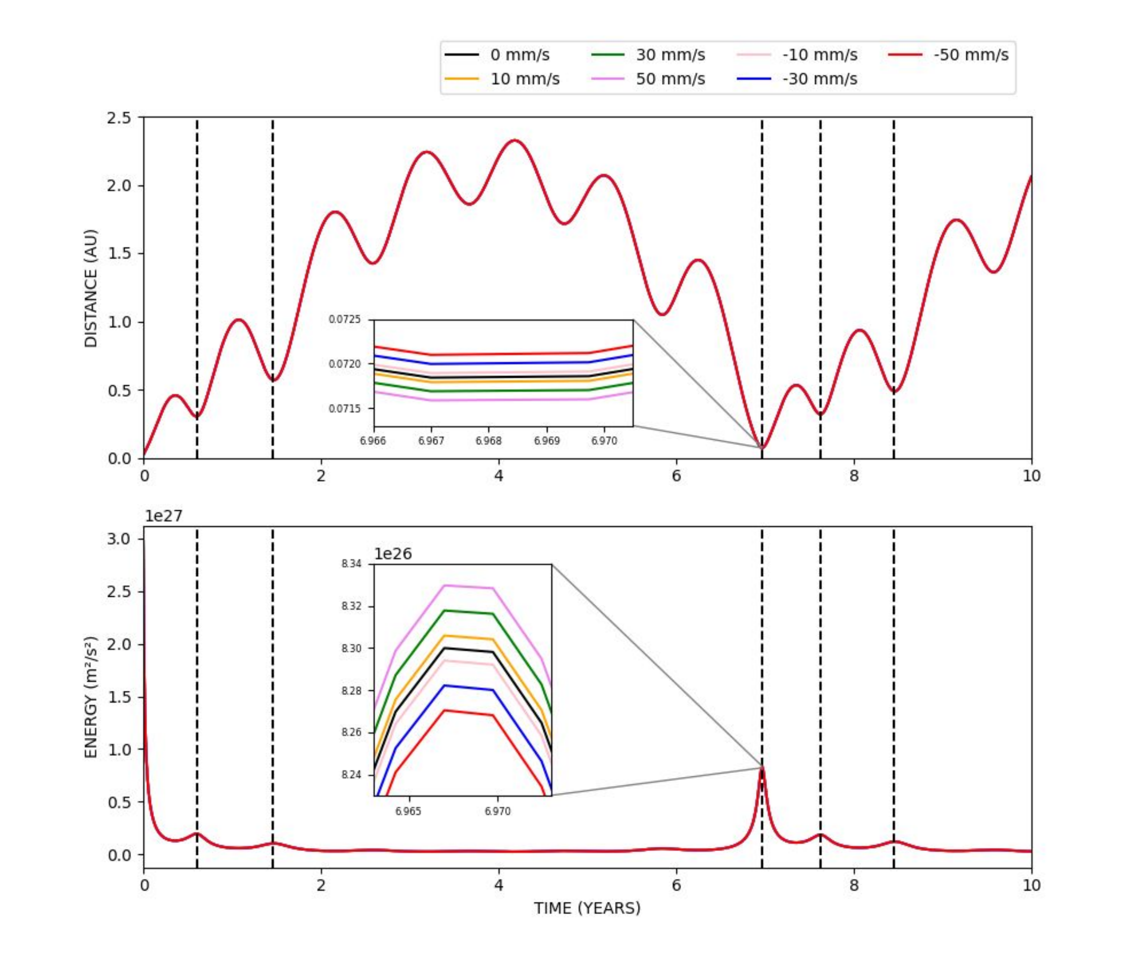

Figure 3 - The behavior of approximations between asteroid Apophis and Earth (Top) and the energy of asteroid-Earth system (Down). The Top Figure show us that the velocity variations cause a variations in the approximations on 2036. This variations in the approximation could don't look too big, however, we are talks in AU, consequently it is occuring a great variation in more popular units. In Down Figure, we look the energy increases when occur the approximation of asteroid and Earth. The dashed lines show us the moment that occur the peaks and comprove its connection with the approximations between the bodies.

CONCLUSION

- We can have good results in deflect asteroids make velocities variations in its initially conditions, where we show that negative variations could to put away the asteroid in relation with the Earth.
- If the intention was in approximate more the asteroid with the Earth, we knowledge that do positives velocities variations is more appropriate.
- Same for little velocities variations, we can have good results, that is much important because, this implied in a impactor no much great.
- We look the influence of the approximation between the bodies and we believe that the ‘swing by’ maneuver has great importance in deflect of asteroids, where, through of the velocities variation, it is occur littles variations in ‘swing bys’, that cause biggest interactions over time between the gravitational forces, favoring the deflect.
- We are running more simulations and soon we hope to present the complete work.

ACKNOWLEDGMENT AND REFERENCES

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