Deflect an hazardous asteroid through kinetic impact 51st Annual Meeting of the Division on Dynamical Astronomy

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Introduction

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. 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 determined the accuracy of the technique. To do this, we will be measure the deviation and displacement obtained at the point of maximum approximation between the body and the Earth.

101955 Bennu

The asteroid 101955 Bennu is part of the group of NEOs that can become objects with a certain degree of danger to Earth. This was discovered on September 11, 1999, and became the target of the mission OSIRIS- Rex, a probe sent to the asteroid to bring a small sample of it, as well as images related to its surface, where we can already have the results through the images sent and thus, a good configuration of the asteroid's surface. This is the reason that motivated the use of this object for current work.

Speed variations

By varying the speed of the asteroid Bennu from a crossing point close and far to Sun, both positive and negative variations were effective in the proposal to vary the distance between the asteroid and the Earth, as discussed in figure 1. The variations occur in several points in Bennu's orbit, but here we will show the points at the perigee and apogee in more details. The figure 1 also shows the importance in considering the perturbations of other nearby planets in the trajectory of the asteroid. A more in-depth discussion of the methods employed will be carried out in the next section.

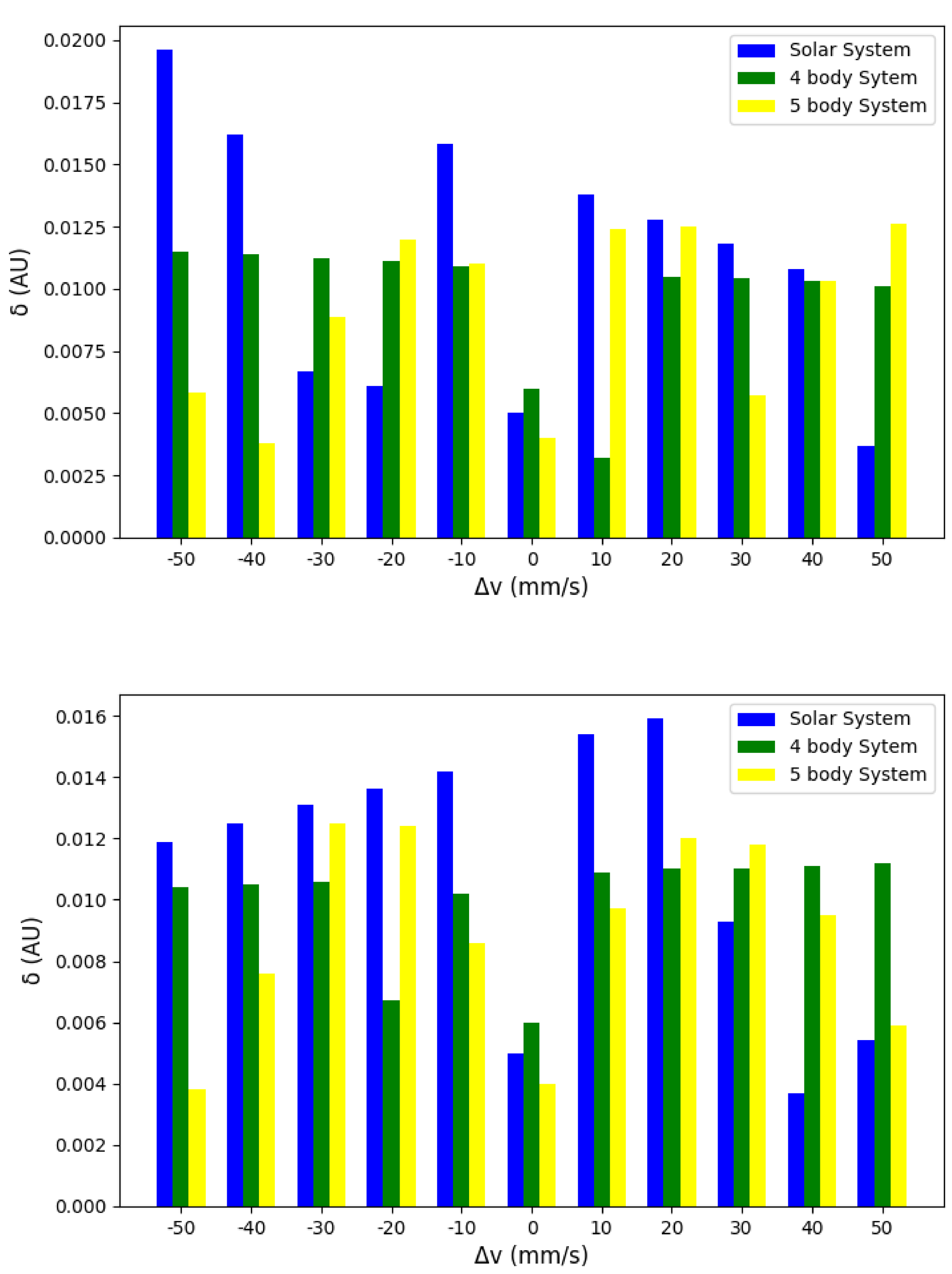

Figure 1: The upper figure shows that, for all applied variations in perigee's point,we obtained a good result for a speed variation of 10 mm/s. Although not the largest, we obtained a good variation in the minimum distance between the asteroid and the Earth. As such, we will focus in variation of velocity of 10 mm/s, because this is more accessible due to the use of an impactor not so large in relation to what we would have to use for greater velocity variations. In the lower figure, we can see the variations in minimum distance between the asteroid and Earth from the apogee's point.We observed that, although it is not the most effective, we also achieved a good result for the variation of 10 mm/s, which is great for the work proposed. Other important results that those figures show is related to the systems applied in our simulations, where is of clear importance to consider all planets of the solar system. The results show that, due to disturbances of the nearby planets, the orbit of the asteroid is affected, giving us a more complete result with respect to the behavior of the smaller body.

Variations of Bennu's orbit

The Mercury integrator package was used and the integrator used was Bulirsch-Stoer. For the input data for integration, the position and velocity components of the bodies, obtained from the JPL Horizons website, were used. We started to carry out an integration from 06/05/2020 for a period of 100 years, therefore, we found an approximation of the asteroid Bennu with Earth on 2060. Then, with the data obtained by Mercury for the next transition day in 2060, we performed the simulations of inverse time initially in 100 years. Then we run the simulations forward in time again for the period of 100 years. Then we apply the speed variations. For this, we use speed variations simulating an impact opposite to the direction of the movement of the asteroid (△v negative) and also in the same direction as the movement of the asteroid (△v positive). The variations used here were 10 mm/s to 50 mm/s. We also divided the impact point into 22 parts of the asteroid's orbital period, going back more and more in time, to obtain more precision in the results. We considered a system with all planets oh the solar system, 4 body(Sun, Earth, Moon, asteroid) and 5 body (Sun, Earth, Moon, asteroid and Jupiter). The results of the impulses applied at the point of perigee and apogee of the asteroid's orbit can be seen in figure 2.

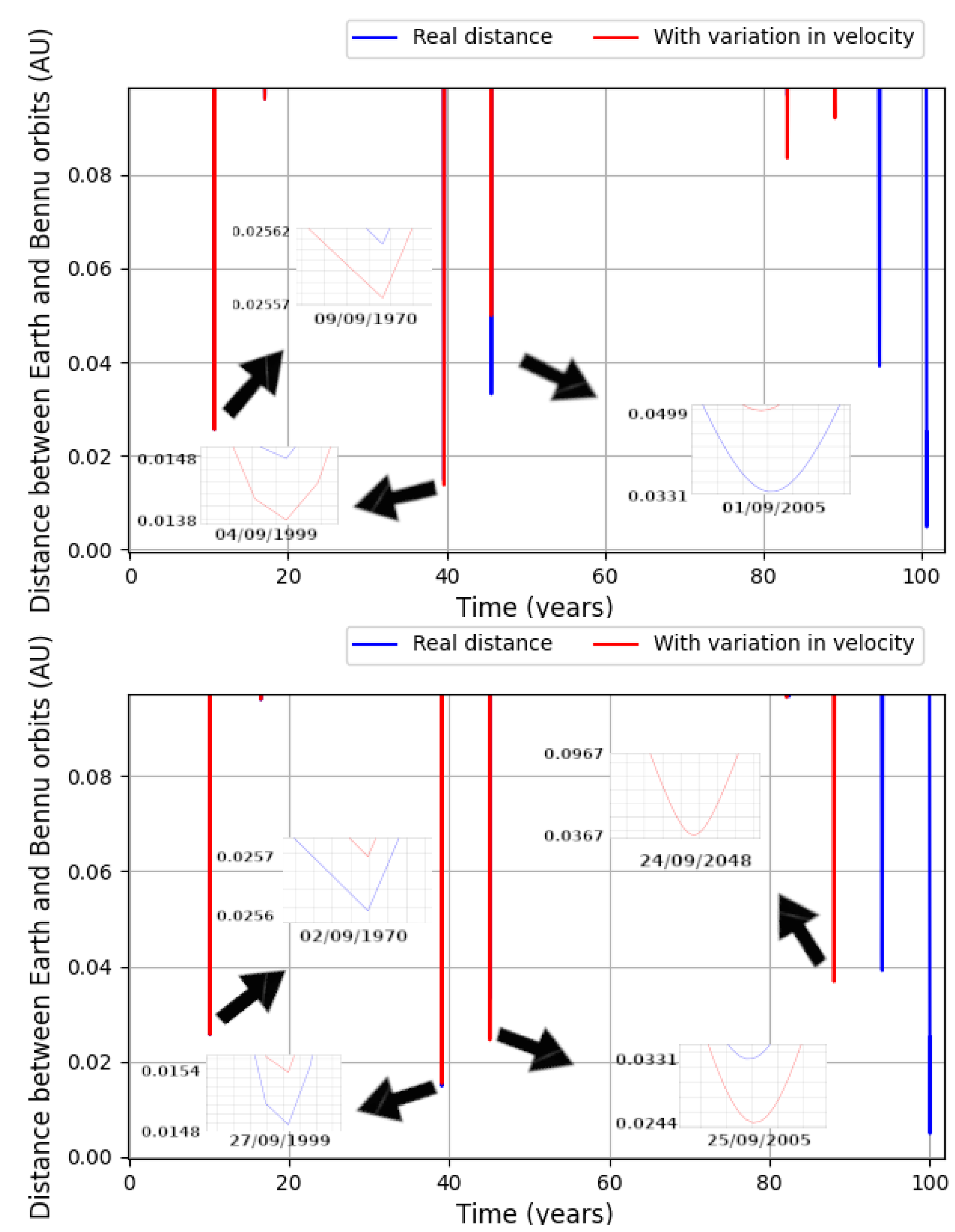

Figure 2:The figures above show the minimum distance between the asteroid Bennu and the Earth with a variation in speed of 10 mm/s for the perigee point (upper figure) and apogee (lower figure). Our results show that the variation in the distance between the two bodies, after applying the impulse, was greater at the point of the apogee over the 100 years. However, for a shorter simulation time, comparing the figures above, we can see that, in the second approach, just over 39 years of disturbance, the perigee impulse generated an approximation of 0.0010 AU while on the same date for the apogee boost, pushed the asteroid away by 0.0006 AU. This makes us think that, for long periods, the initial disturbances of up to 39 years of simulation are responsible for completely altering the behavior of the orbit in the next 100 years of simulation, the Earth itself can contribute to the disturbance of the asteroid after the impulses.

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References

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