Non-gravitational perturbations in NEODyS: the case of asteroid (410777) 2009 FD.

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Abstract

For more than ten years both the University of Pisa and the Jet Propulsion Laboratory (JPL) have been operating impact monitoring systems [1]. These online information systems continually and automatically update the list of asteroids with potential Earth impacts in the next 100 years. The attempt to extend the monitoring time span to a longer interval and to go beyond planetary scattering encounters is at the frontier of research on the theory of chaos, non-gravitational perturbations, and new observation error models. Some special cases, as (99942) Apophis [2], (101955) Bennu [3], and (29075) 1950 DA [4] were successfully handled. In all these cases the authors modeled and solved for parameters appearing in the non-gravitational perturbations, especially the Yarkovsky effect.

The presence of cases for which non-gravitational perturbations are relevant in the orbit determination and in the impact monitoring process led us to develop a new, experimental software. All the orbit determination process has to be done with seven parameters. The new software version also implements a full seven-dimensional Line of Variations [5] and a seven-dimensional impact monitoring. As an example, we analyze asteroid (410777) 2009 FD, which recently appeared as a new special case. 2009 FD currently is the asteroid with the highest value of the Palermo Scale in the risk list with an impact probability of $2.7 \times 10^{-3}$.

NEODyS

The team of the NEODyS Consortium has already developed some experimental code that includes the capability of propagating and determining orbits with more than 6 parameters. This new code has also the capability of performing the impact monitoring in more than 6 dimensional parameter space. We already published some results on the NEODyS Risk Page, namely for (99942) Apophis and (410777) 2009 FD [6].

Modeling the Yarkovsky effect

The Yarkovsky effect is modeled as a purely transverse acceleration $\mathbf{A}_2/\mathbf{r}^2$ [7]. Since in the case of 2009 FD $\mathbf{A}_2$ is not significantly constrained by the fit to the astrometry, we adopted an a priori value $\mathbf{A}_2 = (0 \pm 3.5) \times 10^{-15}$ au/d$^2$, which is based on the available physical model for 2009 FD [6, Sec.3]. In these conditions, the best fit value is $\mathbf{A}_2 = (-2 \pm 32.5) \times 10^{-15}$ au/d$^2$.

Results

- The 2185 VI has the highest PS = −0.43 among all the asteroids currently on NEODyS Risk Page.
- Its IP $\sim 1/360$ is quite high, especially for an impact with an estimated energy of $\sim 3700$ Mt of TNT.
- The computation of the Yarkovsky effect was crucial for a reliable assessment of the impact risk.

Impactor table

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<thead>
<tr>
<th>Impactor</th>
<th>Mass (Mt)</th>
<th>Energy (TNT)</th>
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<tbody>
<tr>
<td>(410777) 2009 FD</td>
<td>$3700$</td>
<td>$3700$</td>
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Conclusions and Future work

- The most difficult task is to properly select the right objects for which we need to include the non-gravitational perturbations.
- The software for the computation of the non-gravitational perturbations will be operational very soon.

References


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