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NEO Characterization

AUTOMATIC YARKOVSKY EFFECT DETECTION PROCEDURE AT THE ESA NEO COORDINATION CENTRE

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ABSTRACT

The Yarkovsky effect is the most important non-gravitational perturbation affecting the dynamics of asteroids smaller than about 30 km in diameter. It is a thermal effect caused by non-isotropic re-emission of heat, and it mainly produces a drift in the semi-major axis. This perturbation is typically small, and its estimation can be attempted by means of orbit determination only under certain circumstances, i.e. when the observational arc is long enough and the observations are of good quality.

Estimating the Yarkovsky effect is useful for different reasons. For instance, it can help in the physical characterization of asteroids [1], or in determining global properties of the near-Earth asteroids (NEAs) population [2]. From a planetary defence point of view, it is fundamental to correctly evaluate the impact threat of a NEA, because the Yarkovsky effect may change the location of the impact keyhole. Several previous works were dedicated to the determination of the Yarkovsky effect on NEAs (see e.g. [3], [4], [5]), and the number of detections increased during the years. However, an automatic procedure for the update of the catalogue is not in place yet.

In this work, we present an algorithm for the automatic detection of the Yarkovsky effect on NEAs. The procedure is based on three steps: 1) shortlist of candidates for Yarkovsky detection; 2) orbit determination on the shortlisted candidates; 3) validation of the detections. Step 1) is done by estimating a probability density function (PDF) of the semi-major axis drift caused by the Yarkovsky effect. An NEA is then shortlisted with a criterion based on the 95-th percentile of the PDF and on the length of the observational arc. The orbit determination procedure of step 2) is similar to that of [4].

Finally, at step 3) a detection is accepted or rejected by comparing the results obtained from orbit determination with the PDF obtained at step 1).

In the preliminary runs of the algorithm we found about 400 positive Yarkovsky effect detections. Figure 1 shows the RMS of the residuals for these NEAs, obtained with the Yarkovsky effect in the model (blue histogram), and without (orange histogram). The distribution of the RMS shifts to lower values when the Yarkovsky effect is included in the model, meaning that it generally improves the orbit determination of this subset of NEAs.

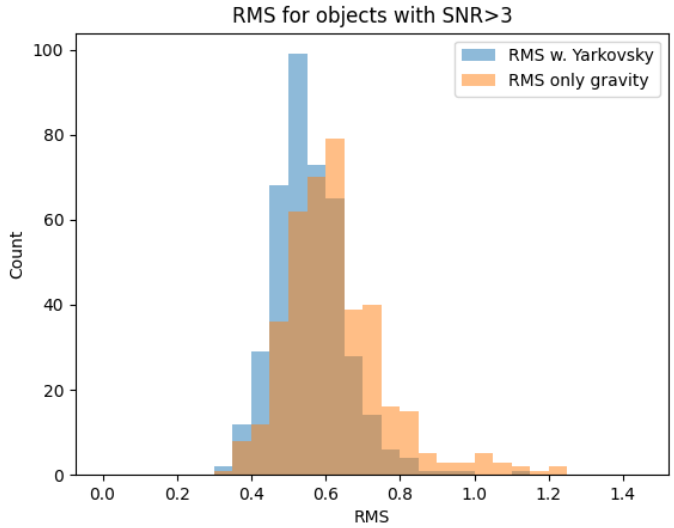

Figure 1. Distribution of the RMS of the residuals for the NEAs with positive Yarkovsky effect detections.

The procedure is foreseen to be triggered every 6 months, and the results will be published on the ESA NEO Coordination Centre portal (https://neo.ssa.esa.int/).

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