Maximizing the detection of near-Earth objects

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Planetary bodies with a perihelion equal or less than 1.3 astronomical units (au) are called near-Earth objects (NEOs). These objects are divided into 4 sub-families, two of them cross Earth's orbit and may be a potential hazard for the planet. The Tunguska event and the incident in Chelyabinsk last year have shown the devastating destructiveness of NEOs with a size of only approximately 40 and 20 meters, respectively. To predict and identify further threats, telescopic NEO surveys currently extend our knowledge of the population of these objects.

Today (March 2014) approximately 10,700 NEOs are known. Based on an extrapolation of the current population, Bottke et al. (2002) predict a total number of $N \approx (1.0 \pm 0.5) \times 10^8$ NEOs up to an absolute magnitude of $H = 30.5$ mag. Additionally, Bottke et al. (2002) computed a de-biased model of the expected orbital elements distribution of the NEOs. They have investigated the theoretical distribution of NEOs by a dynamical simulation, following the orbital evolution of these objects from several source regions.

Based on both models we performed simulations of the detectability of the theoretical NEO population for certain telescopes with certain properties. The goal of these simulations is to optimize the search strategies of NEO surveys. Our simulation models the optical telescope attributes (main and secondary mirror size, optical throughput, field-of-view), the electronics (CCD Camera, pixel size, quantum efficiency, gain, exposure time, pixel binning, dark / bias noise, Signal-to-Noise ratio), atmospheric effects (seeing, sky background illumination) and the brightness and angular velocity of the NEOs.

We present exemplarily results for two telescopes, currently developed by the European Space Agency for a future NEO survey: the so-called Fly-Eye Telescope, a 1-m effective aperture telescope with a field of view of 6.5×6.5 deg^2 and the Test-Bed Telescope, with an aperture of 56 cm and a field of view of 2.2×2.2 deg^2. The results of both telescopes can be easily adapted to other telescopes with similar properties. We show different observation strategies to maximize the detection rate of undiscovered NEOs depending on different telescope operation modes (exposure time, pixel binning) and different sky conditions (seeing, sky background brightness).

References: Bottke, W. F., Morbidelli, A., Jedicke, R., Petit, J.-M., Levison, H. F., Michel, P., Metcalfe, T. S., 2002. Debiased orbital and size distribution of near-Earth objects, Icarus 156, 399–433.