Unbiased dynamical and physical characteristics of the near-Earth-object population

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Recent years have witnessed a renewed interest in the population-level characteristics of near-Earth objects (NEOs) in terms of their unbiased orbital and absolute-magnitude distributions. The interest has been driven by the realization that the Bottke et al. NEO model [1,2] has started fraying at the edges after a decade of success. The number of known NEOs is currently about two orders of magnitude larger than the number of calibration targets used for the Bottke model and a new population model is needed to explain the discrepancy between the observed and predicted NEO distributions. The recent update [3] of the Bottke model improved the statistics of the orbital distributions and made some new predictions such as the existence of near-Earth asteroids on retrograde orbits, but did not attempt a full re-calibration of the model.

Our new NEO model is an improvement on the approach originally developed by Bottke et al. [1,2]. The orbital distributions for NEOs originating in different regions of the main asteroid belt have been re-computed from scratch. We start with a forward integration of an unbiased sample of known main-belt objects (MBOs) to locate all possible NEO source regions in the main asteroid belt. We then record the orbital evolution of particles that enter the NEO region until they are ejected from the solar system or collide with the Sun or the planets in order to build up the so-called NEO residence-time distributions. We calibrate the model with some 4,550 NEOs detected by the Catalina Sky Survey's (CSS) Mt. Lemmon (G96) and Catalina (703) stations in 2005–2012 during untargeted observations. The nightly detection efficiencies measured by CSS are turned into likelihoods that an NEO with a given semimajor axis $0.6\,\mathrm{au} < a < 3.5\,\mathrm{au}$, eccentricity $0 < e < 1$, inclination $0^\circ < i < 180^\circ$ and absolute magnitude $15 < H < 25$ would have been detected by CSS in the above timeframe. We use a novel, computationally efficient approach to numerically estimate the selection effects which provides a high-resolution map of the observational biases with an absolute calibration. The absolute calibration of the selection effects allows us to use an extended maximum-likelihood scheme for estimating the model parameters which simultaneously fits for *all* model parameters. We utilize an analytical function to describe the absolute-magnitude distribution. The functional form permits a simple powerlaw fit but also a wavy distribution as suggested in the literature.

We have the option to use up to two dozen different NEO source regions for our model but decided to combine them into 7 complexes due to apparent degeneracies in models with more sources. The 7 sources are the Hungarias, the Phocaeas, the ν_6 complex, the 3:1 complex, the 5:2 complex, the 2:1 complex, and the Jupiter-family comets. Each source is modelled with a separate absolute-magnitude and orbit distribution. The NEO orbital distribution therefore depends on the absolute-magnitude interval under consideration. We find a generally very good agreement when comparing models based on data from G96 only and 703 only. The combined G96 and 703 dataset leads to a model which almost perfectly reproduces the observed population. The only discrepancy between model and reality is found for low-perihelion-distance NEOs where the model predicts more NEOs than are observed. We will discuss potential explanations for this apparent discrepancy. We will end the talk with a discussion of the completeness of the current NEO inventory in light of our new model as a function of absolute magnitude and NEO type.

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