A Monte Carlo evolution model of small main belt asteroids

Marco Fenucci[1,2], Michael Frühauf[3], Detlef Koschny[2,3], and Bojan Novaković[1]

[1] Department of Astronomy, Faculty of Mathematics, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia
marco_fenucci@matf.bg.ac.rs
[2] ESA Near-Earth Objects Coordination Centre, Largo Galileo Galilei 1, 00044 Frascati, Italy
[3] LRT / TU Munich, Boltzmannstraße 15, 85748 Garching bei München, Germany

Abstract. Small near-Earth asteroids are really difficult to discover and observe. Therefore, models are the only tools that can be used to understand their distribution. Since near-Earth asteroids originate in the main belt, building up a distribution model of small main belt objects is a fundamental step Here we present a comprehensive Monte Carlo evolution model of the main belt population, that aims to constrain the current size-frequency and orbital distributions of main belt asteroids larger than about 10 meters in diameter.

Keywords: Asteroids · Near-Earth Asteroids.

1 Introduction

Near-Earth asteroids (NEAs) with size ∼10-100 m in diameter are very numerous, thus they impact the Earth more frequently than larger objects. At the same time they can still produce a significant damage in case of an impact, as demonstrated by the Tunguska and the Čeljabinsk events. On the other hand, these NEAs are really difficult to discover and observe because they are very faint. Therefore, we necessarily need to rely on models in order to understand their size-frequency and orbital distributions [1]. Since NEAs originate in the main belt, to model their population it is necessary to build up a distribution model of small asteroids in the main belt.

The orbital and the size-frequency distribution of small main belt asteroids evolved by means of different causes, including: 1) collisional catastrophic disruptions; 2) cratering events; 3) YORP spin-up disruptions; 4) gravitational interactions with the planets; 5) Yarkovsky effect. Different one-dimensional evolution models of the main belt have been developed so far, see e.g. [2], [3]. However, a comprehensive multi-dimensional model that includes all the above effects is not available yet.

In this talk we present a Monte Carlo evolution model of the main belt, that aims to include all the main effects that sculpted the orbital and the size-frequency distribution of small objects. We underline the modeling and the computational challenges to be tackled, and we finally present some preliminary results obtained with our code.

2 Model and methods

We set up a Monte Carlo model to track the evolution of an asteroid in the main belt. Each object has: orbital elements a, e, i, diameter, density, obliquity, and rotation period. The orbital elements evolve according to a probabilistic model drawn from a large number of full N-body numerical integrations, while the semi-major axis is affected also by the Yarkovsky effect [4]. On the other hand, the obliquity and the rotation period evolve according to a statistical YORP model [4], [5].

In addition, an object can undergo: 1) a catastrophic disruption or a cratering event (with a probability determined by the actual population); or 2) a spin-up disruption when the rotation period approaches a critical value [6]. All these events produce new fragments with different sizes and orbital elements, increasing the size of the population of small bodies.

When a population of asteroids is used as an input, the above model simulates the time evolution of both the orbital and size-frequency distribution. We present preliminary results obtained by using different distributions of the initial populations.

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