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Dynamical evolution of König and Karma asteroid families

Debora Pavela and Bojan Novaković
Department of Astronomy, Faculty of Mathematics, University of Belgrade, Serbia (debbiepavela2@gmail.com)

Abstract

Here we present numerical simulations of the long-term dynamical evolution of König and Karma asteroid families. The obtained preliminary results provides a very good match to the observed shapes of these families. Moreover, we find that the Karma family contributed some members to population of the near-Earth objects.

1. Introduction

Asteroid families interacting with week and moderately strong secular resonances may be of particular interest in dynamics of asteroids [2]. Such families are invaluable small laboratories to study and understand asteroid dynamics in general. Moreover, in some cases the interaction with secular resonances even helps to reconstruct some parameters of the collision event that produced the family, improving in that way our knowledge of the impact physics.

In this work we present our study of two small families, namely (3815) König and (3811) Karma, both located in the middle asteroid belt near the outer edge of the 3/1 mean motion resonance with Jupiter, and also affected by secular resonances.

2. König and Karma asteroid families: Basic facts

The König and Karma are two asteroid families of primitive composition, formed by catastrophic disruptions of relatively small, approximately 35-40 km in diameter, parent bodies (see Table 1.). The König family is younger and more compact then the Karma family (Figure 1.), with about three times larger membership.

Both families seem to be very homogeneous in composition, and well separated from the background asteroids. Using the automatic tool to identify interlopers developed by Radović et al. [7] and available at the Asteroid Families Portal [1], we find that only 2 and 4 asteroids linked by the Hierarchical Clustering Method [11], to the König and Karma families, respectively, do not belong to the associated family.

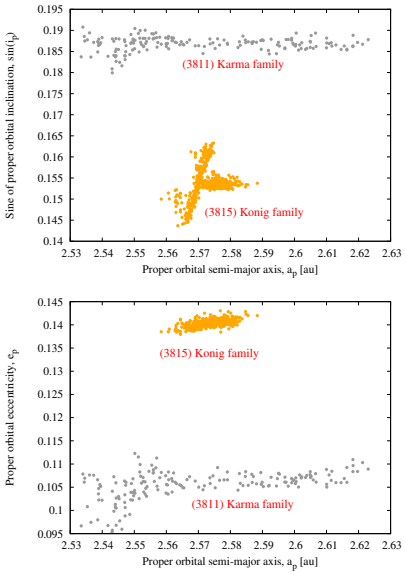

Figure 1: Members of the König (orange dots) and Karma (gray dots) asteroid families as obtained from the Asteroid Families Portal [7, 1], projected onto semi-major axis vs eccentricity (bottom) and semi-major axis vs sine of inclination (top) planes.

3. Numerical Simulations

Numerical simulations of the dynamical evolution of the König and Karma asteroid families are performed following the methodology described in Novaković et al. [6, 5]

3.1. Methodology

The dynamical evolution is simulated by performing a set of numerical integrations, using the the

Table 1: A comparative characteristics of König and Karma families. Age of the König family is taken from Spoto et al. [8], and average albedos are derived using data from Masiero et al. [4].

Parameter	König	Karma
HCM cut-off distance [m/s]	30	50
Number of members	525	171
Number of interlopers	2	4
Average albedo	0.047	0.056
Spectral type	C	C
Parent body diameter [km]	~ 35	~ 40
Age [Myr]	~ 50	?

multi-purpose *OrbFit* software package (available from http://adams.dm.unipi.it/orbfit/). The dynamical model includes the gravitational effects of the Sun and seven major planets, from Venus to Neptune, plus the Yarkovsky non-gravitational effect.

An estimate for the maximum value of the Yarkovsky driven secular drift $(da/dt)_{max}$ for a hypothetical family member of diameter $D = 1$ km is obtained using a model of the Yarkovsky effect [9]. The adopted thermal parameters are $\rho_s = \rho_b = 1190$ kg m^{-3} for the surface and bulk densities, and thermal inertia of $\Gamma = 350$ J m^{-2} s$^{-1/2}$ K^{-1}, based on the recent findings of the OSIRIS-REx and Hayabusa2 missions [3, 10]. The resulting maximum drift speed of 1 km asteroid is estimated to be about 1×10^{-3} au/Myr.

As the Yarkovsky effect scales with $\propto 1/D$, the asteroids' diameters are used to calculate the corresponding maximum value of da/dt for each object, by scaling from the reference value derived for a 1 km asteroid.

3.2. Preliminary Results

The dynamical evolution of the König and Karma families are simulated over 100 and 300 Myr, respectively. In this way we manage to reproduce very well the shapes of both families in the space of proper orbital elements, shown in Figure 1.

Being close to the 3/1 mean motion resonance with Jupiter, both families may be a source of some near-Earth asteroids. However, being a factor 3-5 times older, the Karma family delivered more asteroids to this resonance and consequently to the near-Earth space.

In our presentation, we will provide and describe our findings with more detail, discussing follow-up efforts to confirm the first results. In particular we will focus on the escape rate from these families towards the near-Earth region.

Acknowledgements

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