Yarkovsky effect estimation for some asteroid pairs with close orbits.

Introduction

The mutual asteroid collisions and disruptions may be an important source of meteoritic flux on Earth. In this aspect, studying very young asteroid families and pairs, which are originated in such events has a great interest.

Theoretical Background

It is known, that non-gravity thermal effects play an important role in small bodies dynamics. The fundament of Yarkovsky effect theory was established in papers (Vokrouhlicky 1998, Vokrouhlicky 1999). The Yarkovsky effect has still not been measured in the main belt, thus Spoto et al. (2015) used a calibration based on asteroid (101955) Bennu to compute the ages of more than 50 families in the main belt. In this paper we have calculated the values of maximal Yarkovsky acceleration for some pairs of asteroids with very close orbits (and potentially) very small ages.

As it is well known, non-gravitational tangential acceleration may be expressed as (Marsden 1973):

\[ \alpha = \alpha_n \frac{3}{2} \]

Here \( \alpha_n \) is the mean motion, \( \Phi \) is the standard radiation force factor, which is inversely proportional to the bulk density \( \rho \), the diameter of asteroid \( D \), and the square of the orbital distance \( r \). The Bond albedo \( A \) expressed through geometric albedo \( p_A \), as \( A = 1 - p_A \). Function \( W(K,R) \) is determined by the thermal parameters of the body and a frequency. (From Vokrouhlicky 1998), we have:

\[ W(K,R) = \frac{1}{\Phi} \]

• Simple account of the Yarkovsky effect in semimajor axis may be obtained by normalizing using (101955) Bennu parameters, because it is known with smallest error (Spoto et al. 2015):

\[ \dot{a} = \frac{\Delta a}{\Delta t} = \frac{d}{\rho} \frac{\cos \Phi}{n} W(K,R) \cos \Phi \]

The symbols with a "B" refer to asteroid (101955) Bennu.

The value of \( \Delta a = (19 \pm 5) \times 10^{-4} \) au/Myr and not critically depends on \( d \) (Farracca et al. 2013). After the substitution of (101955) Bennu physical parameters (Del Vigna et al. 2018), we obtain for the Yarkovsky semimajor axis drift (in au/Myr):

\[ \dot{a} = \frac{\Delta a}{\Delta t} = \frac{d}{\rho} \frac{\cos \Phi}{n} W(K,R) \cos \Phi \]

Numerical Simulation

To study the dynamical evolution of some selected close asteroid pairs, the equations of motion of the systems were numerically integrated 50 kyr in the past, using the N-body integrator Mercury (Chambers 1999).

We made three series of integration. In the first we use only planets perturbations. In the second we add Ceres, Vesta, Juno and Pallas. In the third series of our numerical integration we try estimate non-gravitational Yarkovsky effect. In addition to distance during encounter, we perform calculation relative velocity along integration by Nesvorný and Vokrouhlický (2006) and by our previous paper (Rosaev and Plavala 2018) expression.

• In some cases we obtain for the pair age values very different from the values in Pravec (2018) (see Table 2 and Fig. 3) which problem required the future careful studying in each case.

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References