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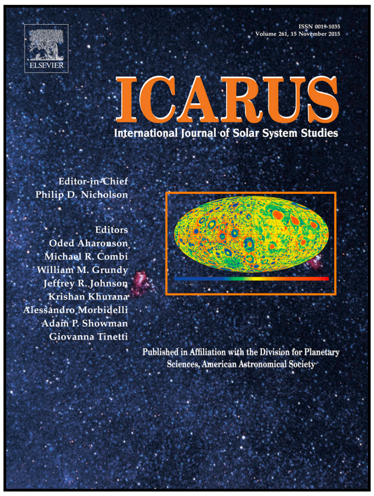

On relative velocity in very young asteroid families

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On relative velocity in very young asteroid families

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Abstract

Asteroid families are groups of minor planets that have a common origin in catastrophic breakup events. The very young compact asteroid clusters are a natural laboratory in which to study impact processes and the dynamics of asteroid orbits.

In the first part of the paper, we define the term very young asteroid families (VYF), that is to say, younger than 1.6 Myrs, and explain why we have defined this group as being separate from young families (younger than 100 Myr), due to specific characteristics, in particularly, non-gravitational forces which have a very small effect (which could be negligible) on their dynamics and the role of the initial conditions in VYFs as being more significant. Due to these facts, the way we study VYFs may be different relative to young families.

For the most part, the calculation of VYFs' normal component of relative velocity using backward numerical integration, exhibited a clear, deep minimum, which was close to the breakup epoch. The age estimations found while employing this method were in excellent agreement with the established age estimations used by other authors. We confirmed our results with the established age estimation of the Hobson family (365 ± 67 kyrs). Concerning the Emilkowalsky family, we confirmed the results of (Nesvorný & Vokrouhlický, 2006)(220 ± 30 kyrs), obtaining a far clearer result using the relative velocity method rather than single-orbital element convergence. The case of the Datura family is more complex to study, mainly due to its 9:16 resonance with Mars.

We have exemplified that the z-component of relative velocity may prove to be a powerful and useful criterion for VYF age estimations. The studied value of relative velocity may contain information about the ejection velocity.

As an additional outcome of this paper, we have introduced two new members of two different VYFs; one new member of the Emilkowalsky family and one of the Hobson family.

Keywords: Asteroids – Solar system – Orbital evolution – Ejection velocity – Dynamics

1. Introduction

The concentrations of asteroids with very similar orbital elements are known as asteroid families. Most possibly, they have a common origin in breakup events. Currently, more than 120 families have been discovered across the asteroid main belt (Nesvorný et al., 2015). A wide range of asteroid family ages are known. More can be learnt on family classification of young (age < 100 Myrs), old (100 Myrs < age < 1 Gyrs), ancient and primordial (age > 1 Gyrs) in Spoto et al. (2015).

A summary of the current state of affairs in the field of family identification is given in Bendjoya & Zappalà (2002); Carruba & Michtchenko (2007); Carruba et al. (2013); Milani et al. (2014). The discovery of young asteroid families (e.g Nesvorný & Vokrouhlický, 2006; Nesvorny et al., 2006; Pravec & Vokrouhlický, 2009), opened a new phase in their analysis.

Studying very young asteroid families (younger than 1.6 Myr) is more simple than studying old ones, and as we have found, allows for a more detailed reconstruction of the most recent breakup processes. The very young compact asteroid clusters are the natural laboratory to study impact processes and the dynamics of asteroid orbits.

In the first part of our paper, we define the term very young asteroid families (VYF), that is to say, younger than 1.6 Myrs. We have presented some dynamic characteristics for them, and explained why we have defined this group as separate from young families (younger than 100 Myrs).

In the second part of this paper, we consider the calculations of relative velocity via backward numeric integration as a method of studying VYFs. We have shown that this method is a powerful tool for VYF age estimation.

Throughout the article we have used standard notations for orbital elements, a – semi-major axis in a.u., e – eccentricity, i – inclination, Ω – longitude of ascending node, ω – argument of perihelion, ϖ – longitude of perihelion (the angular elements are in degrees). $\delta\varpi = \varpi - \varpi_0$, $\delta\Omega = \Omega - \Omega_0$ are the differences between the values at the moment of breakup and the current values in perihelion and node longitudes, where the zero index indicates the value of the breakup.

To study the dynamic evolution of asteroid families in

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