PAIRS OF ASTEROIDS PROBABLY OF COMMON ORIGIN. D. Vokrouhlický[1] and D. Nesvorný[2], [1]Institute of Astronomy, Charles University, Prague, V Holešovičkách 2, CZ-18000 Prague 8, Czech Republic (vokrouhl@cesnet.cz) , [2]Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO 80302 (davidn@boulder.swri.edu).

Introduction: The distribution of asteroid orbits across the main belt is uneven reflecting effects of various processes that shaped it over time. For example, dynamical resonances with planets depleted particular locations while, on the other hand, collisional breakups of large asteroids have created groups of asteroid fragments with similar orbits known as the asteroid families [1]. The standard method to identify an asteroid family is to search for concentrations of orbits in 3D space of proper elements: proper semimajor axis a_P, proper eccentricity e_P and proper inclination i_P. These elements, being more constant over time than the osculating orbital elements, provide a dynamical criterion that a group of asteroids has common origin [2].

A different method can be used to identify asteroid families that formed recently [3, 4]. Instead of using the proper orbital elements this new method relies directly on five osculating orbital elements: semimajor axis a, eccentricity e, inclination i, perihelion longitude ϖ and nodal longitude Ω. The very young families that formed in the last ~1 My show up as clusters in 5D space (a, e, i, ϖ, Ω), because fragments produced by a breakup have similar starting orbits and because it typically takes > 1 My before they can become dispersed by planetary perturbations and radiation forces. The clustering of fragments in mean anomaly M is not expected due to the effects of Keplerian shear.

Here we report a new analysis of the distribution of asteroid osculating orbital elements that indicates that a large number of asteroid pairs exist in the main belt. The two asteroids in each identified pair have nearly identical osculating orbits. They may represent remnants of yet-to-be-characterized asteroid collisions, be parts of asteroids that underwent rotational fission and/or components of dissolved binaries.

Methods: We selected 369,516 asteroids from the AstOrb catalog (January 2008 release) that have the observational arc longer than 10 days and $1.7 < a < 3.6$ AU. This list was searched for asteroid pairs with unusually similar orbits. We defined the distance, d, in 5D space (a, e, i, ϖ, Ω) as

$$(d/na)^2 = k_a\,(\delta a/a)^2 + k_e\,(\delta e)^2 + k_i\,(\delta \sin i)^2 + k_\Omega\,(\delta\Omega)^2 + k_\varpi\,(\delta\varpi)^2, \qquad (1)$$

where n is the mean motion, (δa, δe, $\delta \sin i$, $\delta\Omega$, $\delta\varpi$) is the separation vector of neighboring bodies; we used $k_a = 5/4$, $k_e = k_i = 2$ and $k_\Omega = k_\varpi = 10^{-5}$ (angles in radians).

Results: We calculated distance d from each of the 369,516 orbits to its nearest neighbor orbit. For large value of d the cumulative number of these orbit pairs, $N(< d)$, as a function of d follows a power law, $N(< d) \propto d^\alpha$, with exponent $\alpha \approx 4.7$. Such a functional dependence is expected for a random distribution of points in 5D space where $N(< d) \propto d^5$. However, for $d < 20$ m/s the distribution deviates from the expected dependence. It shows an excess of tight asteroid pairs with as many as 60 pairs with $d < 10$ m/s (the tightest pair with $d = 0.23$ m/s consists of two small Hungaria asteroids (63440) 2001 MD30 and 2004 TV14). We pay a close attention to show that our asteroid pairs cannot be produced by random fluctuations of asteroid orbit density in 5D space (a, e, i, ϖ, Ω). The exception are pairs in very young asteroid families, such as Karin, Datura and/or Iannini, that very likely consist of two fragments originally thrown onto extremely similar orbits. All other cases were analyzed for a putative common origin in the past.

In one favorable case, (6070) Rheinland and (54827) 2001 NQ8, direct backward integration allows us to determine that the two objects gently separated 17 ky ago. In many other cases we are able to put limits on the age of the pair. Conditions of the separation in Rheinland-NQ8 case suggest this pair might have been produced by a rotational fission of a common parent body or a split of a binary system.

Given their putatively very recent formation the identified objects in pairs are prime candidates for astronomical observations.

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