Asteroid families from cratering: Detection and models

A. Milani[1], A. Cellino[2], Z. Knežević[3], B. Novaković[4], F. Spoto[1], and P. Paolicchi[5]

[1]Department of Mathematics, University of Pisa, Italy
[2]INAF, Astronomical Observatory of Torino, Italy
[3]Astronomical Observatory, Belgrade, Serbia
[4]Department of Astronomy, University of Belgrade, Serbia
[5]Department of Physics, University of Pisa, Italy

A new asteroid families classification, more efficient in the inclusion of smaller family members, shows how relevant the cratering impacts are on large asteroids. These do not disrupt the target, but just form families with the ejecta from large craters. Of the 12 largest asteroids, 8 have cratering families: number (2), (4), (5), (10), (87), (15), (3), and (31). At least another 7 cratering families can be identified. Of the cratering families identified so far, 7 have >1000 members. This imposes a remarkable change from the focus on fragmentation families of previous classifications.

Such a large dataset of asteroids believed to be crater ejecta opens a new challenge: to model the crater and family forming event(s) generating them. The first problem is to identify which cratering families, found by the similarity of proper elements, can be formed at once, with a single collision. We have identified as a likely outcome of multiple collisions the families of (4), (10), (15), and (20).

Of the ejecta generated by cratering, only a fraction reaches the escape velocity from the surviving parent body. The distribution of velocities at infinity, giving to the resulting family an initial position and shape in the proper elements space, is highly asymmetric with respect to the parent body. This shape is deformed by the Yarkovsky effect and by the interaction with resonances.

All the largest asteroids have been subjected to large cratering events, thus the lack of a family needs to be interpreted. The most interesting case is (1) Ceres, which is not the parent body of the nearby family of (93). Two possible interpretations of the low family forming efficiency are based on either the composition of Ceres with a significant fraction of ice, protected by a thin crust, or with the larger escape velocity of 500 m/s.

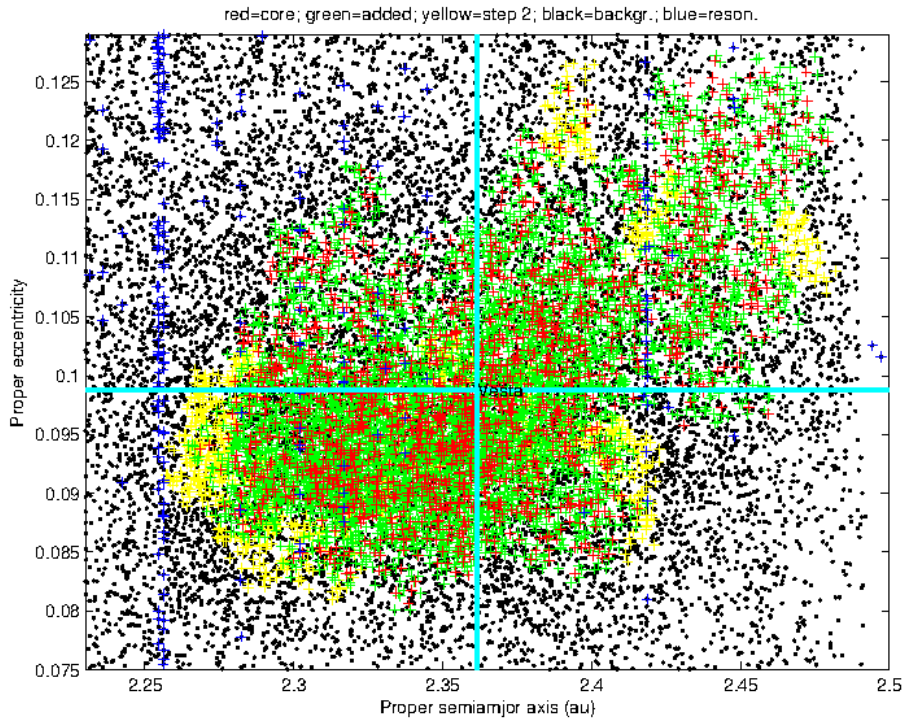

Figure: The complex structure of the family of (4) Vesta can be interpreted as a result of multiple collisions.