Yarkovsky effect and V-shapes: New method to compute family ages

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

[1]Department of Mathematics, University of Pisa, Largo Pontecorvo 5, 56127 Pisa, Italy
[2]INAF–Osservatorio Astrofisico di Torino, 10025 Pino Torinese, Italy
[3]Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia
[4]Department of Astronomy, Faculty of Mathematics, University of Belgrade, Studenski trg 16, 11000 Belgrade, Serbia
[5]Department of Physics, University of Pisa, Largo Pontecorvo 3, 56127 Pisa, Italy

The computation of family ages is a high-priority goal. As a matter of principle, it can be achieved by using V-shape plots for the families old enough to have the Yarkovsky effect dominating the spread of the proper a and large enough for a statistically significant analysis of the shape.

By performing an asteroid family classification with a very enlarged dataset, the results are not just "more families", but there are interesting qualitative changes. These are due to the large-number statistics, but also to the larger fraction of smaller objects contained in recently numbered asteroids. We are convinced that our method is effective in adding many smaller asteroids to the core families. As a result, we have a large number of families with very well defined V-shapes, thus with a good possibility of age estimation.

We have developed our method to compute ages, which we believe is better than those used previously because it is more objective. Since there are no models for error in absolute magnitude H and for albedo, we have also developed a model of the error in the inverse of the diameter and then we have performed a weighted least-squares fit.

We report at least 5/6 examples of dynamical families for which the computation of the V-shape is possible. These examples show the presence of different internal structure of the families, e.g., in the dynamical family of (4) Vesta, we have found two collisional families.

The main problem in estimating the ages is the calibration. The difficulty in the Yarkovsky calibration, due to the need to extrapolate from near-Earth asteroids (NEAs) with measured da/dt to main-belt asteroids, is in most cases the main limitation to the accuracy of the age estimation. We obtain an age estimation by scaling the results for the NEA for which there is the best Yarkovsky effect determination, namely (101955) Bennu.