Asteroid families in the Cybele and Hungaria groups

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Asteroid families are fragments of some disrupted parent bodies. Planetary perturbations force the primarily close orbits to evolve. One of the main features of the orbit evolution is the long-period variation of the osculating elements, such as the inclination and eccentricity. Proper elements are computed by elimination of short- and long-period perturbations, and, practically, they do not change with time. Therefore, proper elements are important for family-identification procedures. The techniques of proper-element computation have improved over time. More and more accurate dynamical theories are developed. Contrastingly, in this work, an empirical method is proposed for proper-element calculations. The long-term variations of osculating elements manifest themselves very clearly in the distributions of pairs: inclination and longitude of ascending node; eccentricity and longitude of perihelion in the corresponding planes. Both of these dependencies have a nearly sinusoidal form for most asteroid orbits with regular motion of node and perihelion. If these angular parameters librate, then the sinusoids transform to some closed curve. Hence, it is possible to obtain forced elements, as parameters of curves specified above. The proper elements can be calculated by an elimination of the forced ones. The method allows to obtain the proper elements in any region, if there is a sufficient number of asteroids. This fact and the simplicity of the calculations are advantages of the empirical method. The derived proper elements include the short-period perturbations, but their accuracy is sufficient to search for asteroid families. The special techniques have been developed for the identification of the families, but over a long time large discrepancies took place between the lists of families derived by different authors. As late as 1980, a list of 30 reliable families was formed. And now the list by D. Nesvorny includes about 80 robust families. To date, only two families have been found in the most outer part of the main asteroid belt or the Cybele group: Sylvia and Ulla. And the Hungaria group in the most inner part of the belt has always been considered as one family. In this work, the proper elements were calculated by the empirical method for all multi-opposition asteroids in these two zones. As the source of the initial osculating elements, the MPC catalogue (version Feb. 2014) was used. Due to the large set of proper elements used in our work, the families are apparent more clearly. An approach similar to the hierarchical clustering method (HCM) was used for the identification of the families. As a result, five additional families have been found in the Cybele region, associated with (121) Hermione, (643) Scheherezade, (1028) Lydina, (3141) Buchar, and (522) Helga. The small Helga family, including 15 members, is the family in the main belt (3.6–3.7 au) most distant from the Sun. Due to the isolation of this family, its identification is very reliable. As to the Hungaria region, two low-density families have been found additionally: (1453) Fennia and (3854) George. They have inclinations slightly greater than that of the Hungaria family (from 24 to 26 degrees). In contradiction to the predominant C-type of the Hungaria family asteroids, the taxonomy of these families is represented mainly by the S and L types. Most likely, these families are two parts of a single ancient family.

References: Nesvorny D., Nesvorny HCM Asteroid Families V2.0. EAR-A-VARGBDET-5-NESVORNYFAM -V2.0. NASA Planetary Data System, 2012; Zappalà V., Cellino A., Farinella P., and Knezevic Z. (1990) Asteroid families. I. Identification by hierarchical clustering and reliability assessment. Astron. J., 100, 2030–2046.