ASTEROID FAMILIES, DYNAMICS, AND ASTROMETRY

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The proper elements and family assignments for the 1227 Palomar-Leiden Survey asteroids of high quality have been tabulated and included in a paper which is in press in Icarus. In addition to the large table, there are also auxiliary tables of Mars crossers and commensurate objects, histograms of the proper element distributions, and a discussion. Probably the most important part of the discussion describes the Mars crossing boundary, how the closest distances of approach to Mars and Jupiter are calculated, and why the observed population of Mars crossers should bombard that planet episodically rather than uniformly.

A start has been made on classifying families, the debris left over from collisions between asteroids, based on the relative sizes of the members, particulary with respect to the largest object, and where the largest object(s) lies in the family. The taxonomic classes of the members are also being compared. This undertaking is about 30% complete. Very few families appear to have resulted from total disruption and dispersal of the parent body.

Analytical work has been done to derive velocity distributions of family forming events from proper element distributions subject to assumptions which may be appropriate for cratering events. The more conventional approach uses an "average" value for the two orbital angles (true anomaly and argument of latitude); the family distributions can also be combined assuming a uniform distribution of the angles to get an overall velocity distribution. All researchers who have tried to get velocity distributions have found that the results from the different proper elements differ radically, with the semimajor axis giving the least and the inclination giving the largest velocities (by a factor of two or three). It is usual to dismiss this discrepancy by attributing it to the accuracy of the proper elements. While this was a plausible explanation 20 years ago, improvements in the calculation of proper elements and the presence of small structure in some families (there is a very tight core in family 38 and the inclination spread of family 128 is quite narrow) argue otherwise. Selection effects may be present in the less well populated families, but the strong asymmetry is also present in the more populous families. On the assumption that the effect is real, several possible causes have been considered, but all seem to be flawed. For example, the passage of weak secular resonances after family formation would scatter e and sin i without scattering a, but it would also leave a boxy morphology which is not seen. It has to be said that this asymmetry is not understood, but it could be an important problem.

During the past year software has been developed for a microcomputer to permit plotting the proper elements. Three orthogonal views are generated and stereo pairs can be printed when desired. This program was created for the study of asteroid families (a similar capability of long standing on a mainframe computer was lost when the high resolution graphics capability

was removed). In a cooperative effort with E. Tedesco and G. Veeder this software has been used to examine a sample of the best physical properties data that they have amassed. This work is presently ongoing, but so far Pv and two colors permit ten plausible taxonomic classes to be recognized.

The astrometry task is directed toward measuring and reducing positions on faint comets and the minor planets with less common orbits. The obsevational material is CCD frames taken with the Palomar 1.5m telescope. There is a need to measure Schmidt plates because the CCD is too small to capture an array of reference stars with known positions. It is necessary to use an existing plate to measure the fainter stars on the CCD frame with respect to the less common catalogue stars. During the past year positions of 10 comets and 16 different asteroids have been published on the Minor Planet Circulars. Many of these were early or late observations which particularly strengthen the orbit determination. In summary, asteroid positions were given on 10 planet crossers (1981 PB, 1981 VA, 1982 HR, 1982 TA, 1985 JA, 1985 PA, 1985 TB, 1985 WA, 1985 XB, and 1986 EB), 1 Pallas-type object (1986 AE), and 5 more ordinary minor planets. The comets were 1980 XI (Encke), 1982 i (Halley), 1985 f, h, j, k, and p and 1986 a, b, and c. These comet and asteroid positions were published on Minor Planet Circulars 9844, 9845, 9849, 9984, 9993, 9994, 10006, 10092, 10200, 10204, 10224, 10226, 10272, 10369, 10370, 10469, 10477, 10478, 10487, 10488, 10591, 10592, 10595, 10596, and 10690.