Asteroid Rotations and Binaries

Petr Pravec[1], **Alan W. Harris**[2]

1. *Astronomical Institute AS CR, Ondřejov, Czech Republic*
2. *Space Science Institute, La Canada, CA, USA*

Rotations of asteroids are determined by mechanisms and properties with importance varying with asteroid size. Asteroids larger than about 50 km are affected primarily by collisions. Their spin rate distribution close to Maxwellian suggests that they are either original bodies of the asteroid main belt, or their largest, collisionally evolved remnants. Rotations of asteroids smaller than 50 km are significantly affected by a non-collisional mechanism, with the most probable candidate being the Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect that causes a radiative spin up or spin down of asteroids.

Among smaller asteroids, the YORP effect theory gives a consistent explanation for: 1) excess of both fast and slow rotators; 2) alignment of spin axes of members of the Koronis family; and 3) abundant population of small, close binary systems with a total angular momentum near critical for a single body.

Internal structure does not have a significant effect on rotations of larger asteroids which are in a gravity regime, but it is a key property for smaller asteroids. Asteroids in the size range 0.2 to about 10 km show a barrier against spins faster than 11/d that shifts to slower rates with increasing equatorial elongation. They are predominantly bodies with tensile strength too low to withstand a centrifugal acceleration for rotation faster than the critical spin rate. A scaled tensile strength of cracked but coherent rocks suggests that a cohesionless structure is predominant among asteroids with $D = 0.2$ to 3 km.

The spin barrier disappears at sizes less than 0.2 km where most asteroids rotate too fast to be held together by self-gravitation only, so some tensile strength is implied. They may be single fragments of the rubble that make up larger asteroids from which the smaller ones are derived.

An abundant population of binary systems has been found among asteroids in the size range 0.3 to 10 km among both near-Earth and main belt asteroids. The fact that they appear exactly in the same size range where there is observed the spin barrier is likely not a mere coincidence. In that size range, YORP is capable of spinning up asteroids on a short time scale of millions of years, to the point where some form of fission or mass shedding occurs, resulting in a binary with the primary body still spinning at nearly the critical rate; the primaries are observed to concentrate in a pile up just below the spin barrier. Gravitational interaction during close approaches to the terrestrial planets cannot be a primary mechanism of formation of the binaries, and in fact is more effective in disrupting them. Thus NEA binaries are probably younger and less evolved than main belt members of the small binaries population, perhaps explaining their tendency to smaller sizes, smaller relative separations (shorter orbital periods), and faster primary spin rates.