Tidal evolution of solar system binaries

Patrick A. Taylor (Cornell University), Jean-Luc Margot (Cornell University)

We approximate tidal evolution timescales for small (radius < 200 km) rocky bodies [1, 2] following a fission event, interpreted here as any process resulting in the placement of mass into orbit above the synchronous height, and explicitly calculate timescales for well-characterized systems. Binaries with nearly equal mass components orbit within ∼6 primary radii and are likely to have fully despun rapidly while smaller secondaries despin more slowly and end their tidal evolution at wider separations. The final separation is limited by the conversion of spin to orbital angular momentum. Binary systems with separations beyond this limit, such as 617 Patroclus [3, 4], require a different formation mechanism such as n-body capture. The product μQ, where μ is the rigidity and Q is the tidal dissipation factor, combines the idealized elastic properties of the asteroid that affect the tidal strength. Since binaries in the Main Belt must evolve to their current configurations within the age of the Solar System, a binary near this limit would place an upper bound on μQ for the system. Precise orbit, density, and component size information are needed because ten percent errors in primary radius and density can cause roughly 20 percent changes in μQ. Assuming μQ of 10^{11} N/m^2, many near-Earth binaries, if produced through fission, have tidally evolved for longer than the typical dynamical lifetime of 10 My [5]. This implies that either these binaries were formed prior to injection into the near-Earth region or μQ is at least an order of magnitude smaller than assumed, which could occur for highly fractured or rubble pile bodies.

[1] A. W. Harris and W. R. Ward, *AREPS*, **10**, 1982. [2] S. J. Weidenschilling *et al.*, in *Asteroids II*, 1989. [3] Y. R. Fernández *et al.*, *AJ*, **126**, 2003. [4] F. Marchis *et al.*, *Nature*, **439**, 2006. [5] B. J. Gladman *et al.*, *Science*, **277**, 1997.

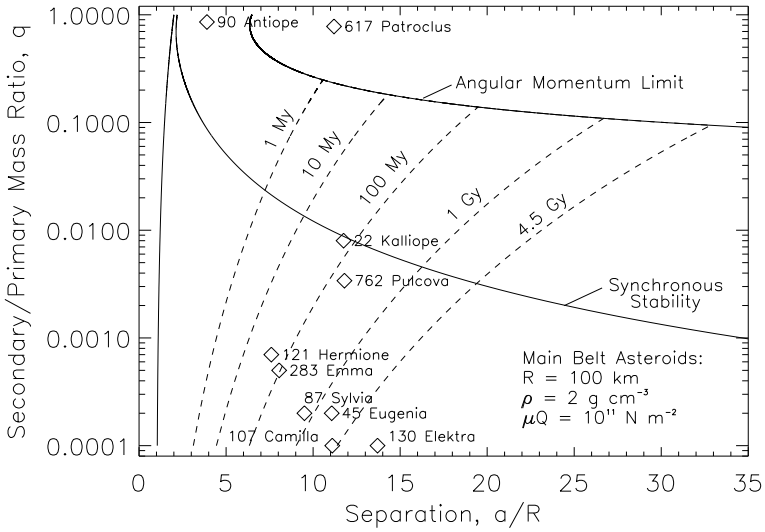

Figure 1: Mass ratio q and primary-secondary separation in terms of the primary radius a/R for select main belt and Jupiter Trojan binaries. Binaries will migrate to the right due to tides. The near vertical line at left indicates a contact binary. Binaries to the left of the synchronous stability curve have not reached a stable, fully despun, synchronous end state. Augmented from [2].