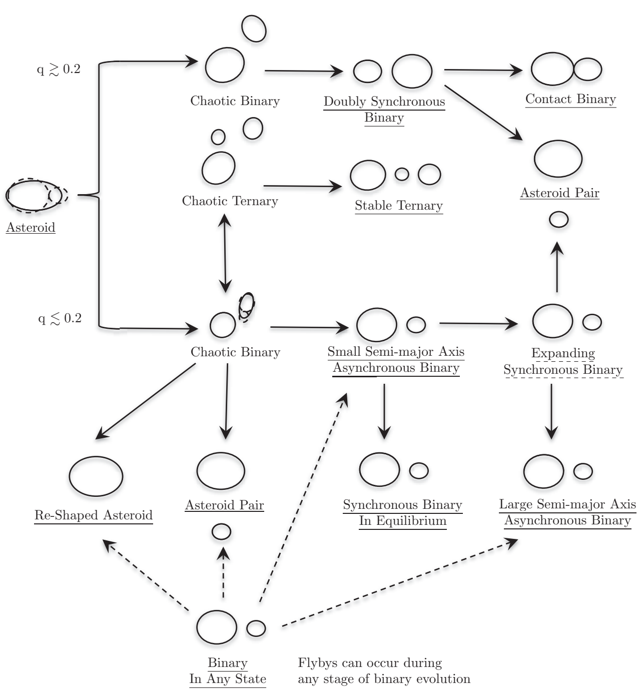
FORMING THE OBSERVED BINARY ASTEROID POPULATION. S. A. Jacobson[1] and D. J. Scheeres[2], [1]Dept. Astrophysical and Planetary Sciences, Univ. of Colorado, Boulder, USA (seth.jacobson@colorado.edu), [2]Dept. Aerospace Engineering Sciences, Univ. of Colorado, Boulder.

Introduction: Rotational fission results in the formation of all classes of observed near-Earth asteroid (NEA) binaries. The NEA population is constantly evolving due to the incredible influence of electromagnetic radiation. The YORP effect, torque from the incident solar irradiation and thermal radiation of an asymmetric body, can rotationally accelerate individual asteroids until centrifugal accelerations match gravitational accelerations, releasing part of the body into orbit and creating a binary asteroid system–i.e. rotational fission. This process has been theoretically predicted and modeled in detail [1, 2], as well as observationally confirmed [3]. The figure below shows the evolutionary pathways from rotational fission to each of the observed binary classes indicated by an underline. q is the mass ratio of the binary (secondary / primary mass). Primary defined to be more massive.

Secondary Fission: After rotational fission, the semi-major axis is small and spin states of the bodies are coupled to the orbital dynamics. In small mass ratio systems, the secondary is rotationally accelerated until it undergoes a secondary spin fission creating a chaotic triple system [2]. This system can stabilize but more often loses a member due to internal collisions or escape. Both processes stabilize the system and lead to a small semi-major axis asynchronous binary.

Synchronization: For small semi-major axis systems, mutual body tides can quickly synchronize the secondary if the YORP torque on the secondary is acting in the same direction or close to zero. If the YORP torque is anti-aligned with the tidal torque then the system may be asynchronous for millions of years. Both members of systems with high mass ratios synchronize on similar short (<1 Myr) timescales.



BYORP Effect: The binary YORP (BYORP) effect, which is an averaged, cumulative torque due to asymmetric thermal radiation, acts on binary members that are synchronized. If both members are synchronized, the combined torques drive the system inward towards contact or outward towards the Hill radius. If the two BYORP torques are anti-aligned this evolution may take millions of years.

If the primary is asynchronous, then mutual body tides will continue to grow the orbit. A BYORP torque anti-aligned with the tidal torque drives the mutual orbit to an equilibrium that is stable in eccentricity [4]. An aligned BYORP torque will expand the semi-major axis of the system towards the Hill radius. As the system expands, conservation of the action due to the expansion of the orbit adds energy into the spin state of the secondary while the strength of tidal dissipation is decreasing rapidly with semi-major axis. At large semi-major axes, the secondary may de-synchronize creating an asynchronous binary [5].

Flybys: The mutual orbits of planet crossing binary asteroids can be substantially modified by close encounters. Since the occurrence of planetary flybys depends upon the heliocentric orbit and not the mutual orbit, flybys may effect all binary morphologies and are diversions from, rather than a natural part of the evolutionary scheme. Catastrophic flybys lead to disruption or collision of the binary members. [6] showed that a majority of the time flybys increase the semi-major axis of synchronous binary asteroids, and that perturbing flybys occur for most asteroid systems on 1 – 10 million year timescales. Sudden growth in the semi-major axis can de-synchronize the secondary creating an asynchronous binary system. The future of this evolution depends on the semi-major axis.

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