The Fate of Expanding Binary NEAs

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Singly synchronous binary asteroid systems have several evolutionary end-states, which depend heavily on the BYORP effect. If BYORP is contractive, the primary and secondary could re-impact to form a contact binary, or they could end in a tidal-BYORP equilibrium. Alternatively, if BYORP is expansive, the binary system could evolve to become a wide asynchronous binary system, or the system could expand far enough to become disrupted to form a heliocentric pair. The distinction between the two expansive outcomes depends on whether the secondary asteroid stays synchronized, which keeps the BYORP effect active and the orbit expanding. As the orbit expands, the secondary will librate around the tidally locked orientation to some degree, and the amplitude of this libration will grow with the orbit. This libration also causes variations in the osculating binary orbit eccentricity due to the elongation of the secondary body. This coupling is key to determining the fate of the expanding system. If the eccentricity grows large enough, the secondary will begin circulating; conversely, if the eccentricity and libration are bound to small enough values the system can expand significantly. In this work, we discuss the stability of the libration and orbital motion as a binary expands. In particular we investigate how various levels of tidal and BYORP strengths change the stability of the librational motion - an important aspect is the speed of BYORP expansion - slower expansion is more stable. Thus an understanding of the BYORP coefficients are of fundamental importance for determining the fate of a binary system. The variation in BYORP coefficients has been investigated for a variety of asteroid shapes. This has a further implication in that this knowledge can be used to constrain Q/k based on the work of Jacobson and Scheeres. This analysis helps to inform the expected production rates of heliocentric pairs and wide asynchronous binary systems from singly synchronous systems.