YORP EQUILIBRIA OF BINARY ASTEROIDS: THEORY. Oleksiy Golubov[1,2,3], Vladyslav Unukovych[1], Daniel J. Scheeres[3]. [1]V. N. Karazin Kharkiv National University, 4 Svobody Sq., Kharkiv, 61022, Ukraine; oleksiy.golubov@karazin.ua. [2]Institute of Astronomy of V. N. Karazin Kharkiv National University, Kharkiv, Ukraine. [3]Department of Aerospace Engineering Sciences, University of Colorado at Boulder, CO.

Introduction: It is generally assumed that the lifetime of small binary asteroids is determined by the binary YORP (BYORP) effect [1]. By altering the angular momentum of a binary system via recoil radiation pressure torque, BYORP can cause the system to merge or to decay. Still, it turns out that it also can cause the system to stop its dynamic evolution in a stable YORP equilibrium, where the total torque acting on the system is zero. The abundance of such YORP equilibria of binary asteroids could explain the high abundance of binaries in the asteroid population [2], and the fact that the BYORP acceleration of no binary asteroid has yet been detected [3].

The first proposed YORP equilibrium (Bt-semiequilibrium, [4]) required cancelation of BYORP and tides acting on the primary, but didn't enforce constancy of the primary's rotation rate. Later [5], this equilibrium was extended to include the primary by requesting the compensation of tidal and YORP torques acting on it (NTBt-equilibrium). In the absence of tides, for doubly synchronous binaries, another equilibrium was found [6], in which BYORP compensates YORP (NB-equilibrium).

Here we review and generalize the theories of YORP equilibria for binary asteroids.

Results: The BYORP-NYORP equilibrium (NB-equilibrium) occurs when the binary YORP torque acting on a doubly synchronous secondary is compensated by the normal YORP torque [6]. As the NYORP torque is independent on the distance between the components of the binary system, while the BYORP torque is proportional to this distance, this compensation can occur only at a certain distance between the components, and only if NYORP is positive and BYORP is negative. Additional constraints are put by the requirements that the components of the binary do not touch each other and do not get separated by the sun's gravity. Still, the probability of this equilibrium is estimated at the level of 4-8% (Figure 1).

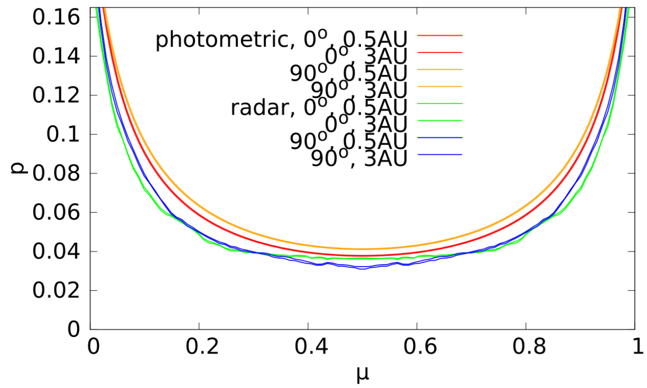

Figure 1. The probability of NB-equilibrium as a function of the mass fraction [6]. Different colors show different sets of shape models (radar and photometric) and different heliocentric distances (0.5 and 3 AU), whereas different thickness (lines almost indistinguishable from each other) show different obliquities.

The BYORP-TYORP-NYORP-tidal equilibrium (NTBt-equilibrium) happens in singly-synchronous binaries, when the primary resides in equilibrium between NYORP, TYORP and tides, while the tides acting on the secondary are compensated by BYORP [6]. Again, the equilibrium is reproduced in a broad range of the governing parameters, and has the probability 1-8% (Figure 2).

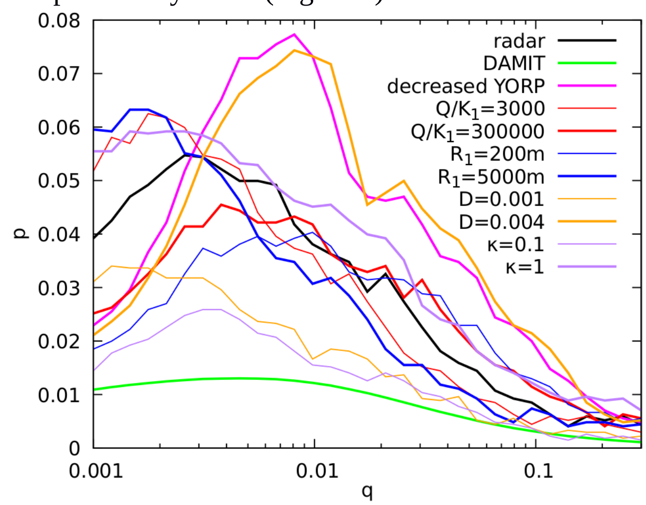

Figure 2. The probability of NTBt-equilibrium as a function of the mass ratio [5]. Black and green lines

represent radar and photometric shape models respectively, and correspond to the standard values of parameters, whereas the other lines show the probability for altered physical parameters.

Conclusions: The YORP equilibria of binary asteroids systematically appear in various simulations, with different asteroid shape models, different mass ratios, different values of other governing parameters, and consistently demonstrate the probability of occurrence of the order of a few percent. It means that many small asteroids are expected to reach such equilibria after fulfilling several dozen YORP cycles, and a high percentage of the observed binaries could be in such equilibria.

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