# Mechanism of self-reinforcing YORP acceleration for fast-rotating asteroids

T. Statler[1,2], D. Richardson[2], K. Walsh[3], Y. Yu[4], and P. Michel[5]

[1]Ohio University
[2]University of Maryland
[3]Southwest Research Institute
[4]Tsinghua University
[5]University of Nice Sophia Antipolis

The YORP effect is an important process that directly alters the spin states, and indirectly alters the orbits, of small Solar System bodies. It has been suggested that YORP may be able simultaneously to account for the high fraction of binaries among the near-Earth-asteroid (NEA) population, the frequent radar detections of objects shaped like child's tops, and the abundance of top-shaped asteroids with binary companions. In a compelling demonstration, Walsh et al. (2008, Nature 454, 188) simulated the evolution of idealized, gravitationally bound rubble piles, to which they continually added angular momentum. The centrifugal force caused material to move from mid-latitudes toward the equator, generating the characteristic top shape. Continued spin-up caused the equatorial ridge to shed material, which reaccreted in orbit to form a binary companion. But this mechanism rests on the assumption that YORP will provide all the angular momentum needed to form axisymmetric tops, accelerate them to the mass-shedding limit, and drive enough mass into orbit to form an observable companion. This assumption is problematic, as a truly axisymmetic body would experience no YORP effect at all, and small surface changes on an object with approximate large-scale axisymmetry can easily change the sign of the torque and decelerate the spin (Statler 2009, Icarus 202, 502). So the search is on for a mechanism that can ensure a continual increase in angular momentum to overcome the stochastic effect of topographic changes. One intriguing suggestion is ”tangential YORP” (Golubov and Krugly 2012, ApJL 752, L11), which arises from asymmetric east-west heat conduction across small exposed structures, and always produces an eastward torque. But tangential YORP relies on structures at a preferred size scale, which shrinks to millimeters as the rotation rate approaches periods of a few hours. How the effects generated at these tiny scales are diluted by the mesoscale (meters to hectometers) topography in which they are embedded is still unknown. Here we suggest a different process, in which the accelerating rotation itself alters the mesoscale topography so as to bias the ordinary YORP effect toward continued acceleration. This process begins during the stage when increasing centrifugal forces initiate migration of material toward the equator. We assume that a significant part of that migration occurs in the form of surface avalanches, preferentially occurring on equator-facing slopes that have been destabilized by the centrifugal deflection of the local effective gravity. At rotation periods of a few hours, the Coriolis force on the moving avalanche will be significant, causing a westward deflection of the flow. The accumulated effect from many avalanches will result in a global tendency for shallower slopes to face southwest in the northern hemisphere and northwest in the southern hemisphere, a topographic chirality to which YORP will couple. Because a shallow slope is illuminated for a larger fraction of the day than a steep slope, the tendency will be to increase the eastward component of the recoil force and accelerate the spin. And because it does not rely on heat conduction, this topographic self-reinforcement process can act either in concert with, or independently of, tangential YORP. In this presentation we will demonstrate the circumstances under which topographic self-reinforcement can produce a significant bias in the fraction of rapid rotators that continue to gain angular momentum when already close to the mass-shedding limit.