TANGENTIAL YORP. Yu. N. Krugly[1] and O. Golubov[2], [1]Institute of Astronomy, Kharkiv National University, Kharkiv, Ukraine, krugly@astron.kharkov.ua, [2]ARI, University of Heidelberg, Heidelberg, Germany.

Introduction: Rotation state of asteroids is known to be altered by the YORP torque, produced by non-compensated recoil forces of light scattered and re-emitted by the surface [1]. To compute this torque shape models of limited resolution are used, with smallest resolved structures ranging from meters to hundreds of meters. Under such conditions 1-dimensional model nicely describes heat conductivity under each surface element [2].

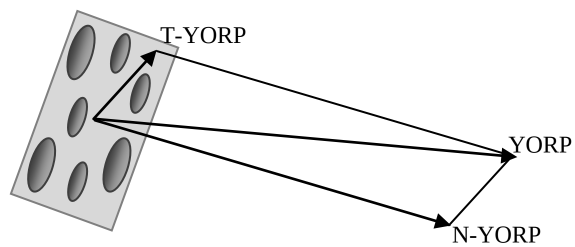
But if the shape model resolves structures on decimeter scale, an entirely new physics emerges. Now heat conductivity problem is essentially 3-dimensional, and heat exchange between different surface elements is allowed. Under certain conditions it can occur that a non-zero average heat flux penetrates stones, so that e.g. a significant amount of light absorbed by the eastern side of a stone is transferred to its western side via heat conductivity and irradiated there. Then each such stone on the surface experiences a net recoil force directed eastwards, and rotation of the asteroid accelerates.

We call this effect the tangential YORP, or T-YORP, and distinguish it from the normal YORP, or N-YORP, produced by light recoil forces normal to the smoothed 'global' surface. But in reality both components of the effect operate simultaneously. Moreover, difference between them vanishes on small scales, and they become inseparable.

Model: To estimate the importance of T-YORP, we consider a simplified model of an asteroid with walls in meridional direction. We consider heat conductivity in these walls, solving 1-dimensional heat conductivity equation. Its boundary conditions include the Stefan–Boltzmann law, and thus are non-linear. Despite the net incident light flux for the east and west faces of the wall is the same, the non-linearity causes the net emitted light fluxes to differ. The difference between them defines the net force per unit surface, acting perpendicularly to the wall, and thus tangentially with respect to the 'global' surface.

This force appears to be the strongest when the thickness d of the wall is of the same order of magnitude with the thermal wavelength L_{wave} in the wall and with the heat conductivity length L_{cond} [3]. (The latter is roughly the maximal depth penetrable by heat. If a structure on the surface has bigger sizes, heat conductivity through it comprises a negligible part of the incident heat, and 1-dimensional model can be applied in each its point.) Far away from the area $d \sim L_{\text{wave}} \sim L_{\text{cond}}$ the T-YORP vanishes. The maximal possible values of T-YORP are positive, thus it predominantly accelerates, not decelerates rotation of asteroids (here means that the asteroid has a direct sense of rotation). Values of the T-YORP acceleration for the rockiest possible surface are estimated to be about an order of magnitude bigger than the ones of N-YORP for realistic asteroid's shapes. Sizes of basaltic walls the most plausible for T-YORP are about 10 cm.

Discussion: Each intermediate-size surface element, containing many stones, but still globally smooth, experiences both the N-YORP and the T-YORP forces. The average N-YORP force is about 2 orders of magnitude bigger. But when creating a torque with respect to the center of the asteroid, it has a relatively small lever arm, as it is directed more or less radially. Moreover, torques created by different parts of the surface largely compensate each other, and the resulting overall torque is only due to the slight deviation of the shape of an asteroid from ellipsoidal. In contrast, all T-YORP forces can rotate an asteroid in the same direction and with the maximal level arm, which allows T-YORP sometimes even to overcome N-YORP. Even a spherical asteroid covered with stones can experience T-YORP acceleration.



In contrast to the N-YORP acceleration, the T-YORP acceleration depends on the rotation rate of an asteroid. In principle, it can occur that N-YORP and T-YORP compensate each other, and the asteroid resides in a stable equilibrium rotation state without any observed YORP acceleration or deceleration.

Though better models of the surface must be considered to make more reliable predictions about the amount of the T-YORP effect, and it is questionable whether it really can dominate over N-YORP. The accounting for T-YORP will definitely be necessary for precise computation of the YORP acceleration of asteroids.

References: [1] Rubincam D. P. (2000) *Icarus 148*, 2–11. [2] Breiter S., Bartczak P., Czekaj M. (2010) *MNRAS 408*, 1576-1589. [3] Golubov O. and Krugly Yu. N. (submitted) *ApJL*.