THE YORP EFFECT ON ASTEROIDS WITH HETEROGENEOUS DISTRIBUTION OF SURFACE THERMOPHYSICAL PROPERTIES. K. Chrbolková[1,2] and D. Čapek[3], [1]Astronomical Institute of Charles University, V Holešovičkách 2, 180 00 Prague 8, Czech Republic (katerina.chrbolkova@gmail.com), [2]Department of Physics, University of Helsinki, Gustaf Hällströmin katu 2a, Helsinki, Finland, [3]Astronomical Institute of the Czech Academy of Science, Fričova 298, 251 65 Ondřejov, Czech Republic.

Introduction: The YORP effect is caused by torques created by scattering or by an emission of thermal radiation from small irregular bodies in the Solar System - asteroids. The main consequences of YORP are change of period of rotation and change of orientation of rotation axis. Until now, YORP has been studied only on bodies with homogeneous distribution of surface materials, thus with uniform optical and thermophysical properties. However, based on pictures taken by interplanetary probes such as those of Itokawa [1], asteroids are not homogeneous. Some of them show significant changes in albedo etc. We applied several different methods for creating heterogeneous surfaces on 200 artificial asteroids and then using the YORP model evaluated whether the presence of heterogeneities influences YORP significantly compared to the homogeneous case or not.

Model: We use artificial asteroid models that are composed of triangular facets. Modelling of the surface heterogeneities is done in three ways. In the first one, we create an impact crater with higher albedo regolith on a regolith-covered asteroid. This differentiation of albedo is based on knowledge of space weathering effect that diminishes albedo of a material exposed to the space environment. In the crater region, the subsurface layers of regolith, which are not weathered, are excavated and so the surface here is brighter.

In the second way, we suppose presence of the higher albedo regolith on steep slopes (slope angle of a triangular facet > 35°) and in the third one, we state properties of bare rock (with different thermal parameters) in these areas. This particular value of slope has been chosen as an estimate of the angle of repose on asteroids [2], [3]. If a facet has slope greater than the angle of repose, regolith that was on the facet originally tends to slide away from it and lower layers of regolith (with higher albedo) or a bare rock (with different thermal conductivity, density etc. than the rest of the surface) are uncovered.

Then we evaluate the influence of torques caused by scattered or thermally emitted radiation on our sample of 200 asteroids by means of statistics. For computation of YORP we use already existing model by Čapek and Vokrouhlický [4].

The last part of our research is based on a comparison of behaviour of sets of homogeneous asteroids with different covering materials.

Results: We have found that the presence of heterogeneities caused by an impact crater or landslides on asteroid surfaces does not significantly affect the YORP effect with two exceptions: a slight inclination to decelerate the rotation in the case of landslides uncovering bare rock due to critical rotation (more landslides happen with higher rotation speed) and significant preference for deceleration in the configurations with uncovered higher albedo regolith on steep slopes. The not-mentioned features (such as the final position of the rotation axes) stayed statistically the same as for the homogeneous bodies.

Our data suggest that the influence of heterogeneous distribution of optical properties caused by landslides on the value of typical acceleration time, so-called doubling time t_d, is 2% and it does not exceed 5% in the case of heterogeneity in the thermal parameters.

Change of node position. Moreover, we have studied how the dependence of the change of obliquity (position of rotation axis) on initial obliquity of asteroids that are covered homogeneously behaves. We had covered the sample of 200 asteroids only by regolith and then modelled YORP. And then we had covered them by bare rock and did the same.

From the dependencies we have chosen those that tend to the position perpendicular to the orbital plane – in case of regolith-covered asteroids number of such bodies is 189 and for the rock-covered the number is 196, thus the majority of all cases as was mentioned earlier. All these dependencies have one node that was thought to be precisely at 90°. But from our data, it is evident that the position differs from 90°. Bare rock has higher conductivity than regolith in our models. We conclude that the higher is the conductivity of the surface material of homogeneous body, the higher is the obliquity of the node of this dependence. This means that more asteroids will end in a state with prograde rotation than with retrograde rotation.

References: [1] Miyamoto H. et al. (2007) *Sci., 316*, 101. [2] Richardson J. E. and Bowing T. J. (2014) *Icarus, 234*, 53-65. [3] Murdoch N. et al. (2015) *Asteroids IV*, 767-792. [4] Čapek D. and Vokrouhlický D. (2004) *Icarus, 172*, 526-536.