THE YORP-EFFECT AND AXIS ROTATION OF NEAR-EARTH ASTEROIDS. I. N. Tielieusova and D. F. Lupishko, Institute of Astronomy of Kharkiv V. N. Karazin National University, Sumska str. 35, Kharkiv 61022, Ukraine. lupishko@astron.kharkov.ua

Introduction: As is well known, the distribution of near-Earth asteroids (NEAs) rotation rates differs greatly from the same one for the small and especially for the large main-belt asteroids (MBAs). In contrast to MBAs the distribution of rotation rates for NEAs shows excesses of fast and slow rotators (Fig. 1) [1, 2]. One of the possible reasons of the difference can be so-called YORP-effect [3], which appears because of reflection and IR-reemission of the solar radiation by an irregular-shaped body. The YORP-effect acting depends on the size of asteroid, its shape and on the amount of solar radiation that body receives [3, 4]. At the same time, an increment of angular momentum may be both positive and negative. There is no doubt that action of the effect is very faint but it is accumulated during the whole lifetime of NEA ($\sim 10^7$ yrs) and therefore can be resulted in noticeable change of axis rotation and inclination of small NEAs. Currently there are experimental verifications of the YORP-effect influence on the rotation of the four NEAs: 1620 Geograph [5, 6], 1820 Apollo [7], 3103 Eger [8] and 54509 YORP [9]. The purpose of this study is an attempt to detect the YORP-effect influence on axis rotation of NEA population as a whole. At the same time the authors understand that desired effects of solar radiation influence are incredibly small to be at the limit of detectability at best.

NEA Rotation Rates Distribution: Fig. 1 shows the axis rotation rate distribution for NEAs obtainted using data of new publications and Asteroid Lightcurve Database compiled by A.W.Harris&B.D.Warner (http://www.minorplanet.info/lightcurvedatabase.html) The distribution clearly shows the excesses of bodies with fast (ω=8÷11 *rev/day*) and slow (ω=0÷2 *rev/day*) rotators.

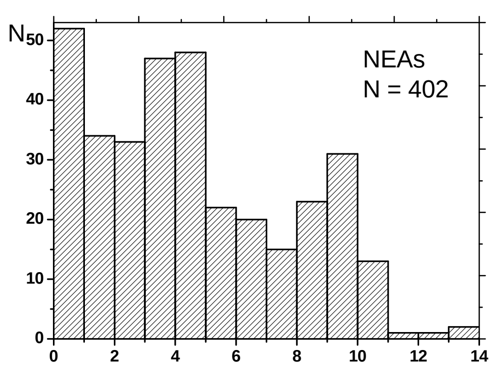

Fig. 1. Distribution of axis rotation rates of NEAs.

It is noteworthy that parameters of rotation of binary NEAs actually contribute significantly to formation of these excesses. It is because the rotation of central bodies of such binary systems (mainly ω_{prim}=7÷10 *rev/day*) belongs to the excess of fast rotators and orbital rotation of secondaries (mainly ω_{orb}=0.8÷2 *rev/day*) falls into the excess of slow rotators. Therefore, in order to exclude the possible influence of NEA binary systems their rotation is not included in the distribution in Fig. 1.

Analyzing the rotation rate distributions for MBAs of different sizes and for NEAs (which are on average significantly smaller than the smallest MBAs that we observe today) one can note that the smaller average size of asteroids of fixed population, the more clearly we can see excesses of fast and slow rotators. Such dependence of rotation rates on asteroid sizes is just typical for the YORP-effect influence. That is why the analysis of an average size of NEAs in both excesses and in the middle of the distribution is of immediate interest.

Connection of NEA axis rotation rates and their average diameters: To succeed in this study we used the database "Physical Properties of Near-Earth Objects" (http://berlinadmin.dlr.de/SGF/earn/nea/) by Gerhard J. Hahn. It includes such parameters as absolute magnitude, albedo, diameter, color, type of asteroids, etc. When diameter of asteroid is unknown (because of the absence of information about its albedo) it was calculated by well-known formula:

$$2 \lg(D) = 6.247 - 0.4\,H - \lg(p_v),$$

where: D is diameter of asteroid in km, H is an absolute magnitude and p_v is a geometrical albedo of asteroid. The latter was taken as an average value for the given composition type of asteroid according to [10]. Thus, we used the axis rotation data only of those NEAs, for which diameters or composition types (taxonomic classes) are known.

The obtained dependence (Fig. 2) shows that average size of NEAs is decreasing from the middle of the distribution of their rotation rates to its edges, i.e. the excesses of slow rotators ($\omega \le 2$ rev/day) and fast rotators ($\omega \ge 8$ rev/day) are composed by NEAs which are in average 1.5 times smaller than those in the middle of the distribution. In a qualitative sense this result is in excellent agreement with the character of influence on axis rotation of NEAs just the YORP-effect.

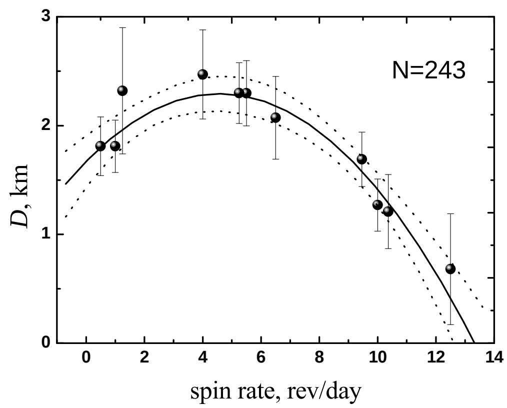

Fig. 2. Diameter-axis rotation rates diagram for NEAs.

Connaction of axis rotation rates of NEAs and their relative insolation: As already mentioned the action of YORP-effect depends also on the amount of solar radiation that the body receives (insolation). This parameter is defined by semi-major axis and eccentricity of orbit. The larger insolation, the stronger should be an action of the YOPR-effect on deceleration or acceleration of asteroid axis rotation. That is why the study of possible correlation between rotation rate of NEAs and their relative insolation is of great interest too.

In order to solve this problem we calculated the relative amount of solar energy, received by each NEAs during a single revolution around the Sun. The formula for calculation of relative insolation $E_{rel.}$ is derived under the assumption that the latter is in inverse proportion to squared time-average distance from the object to the Sun:

$$E_{rel.} = \frac{1}{a^2\sqrt{1-e^2}}$$

where a is a semi-major axis of asteroid's orbit and e is its eccentricity.

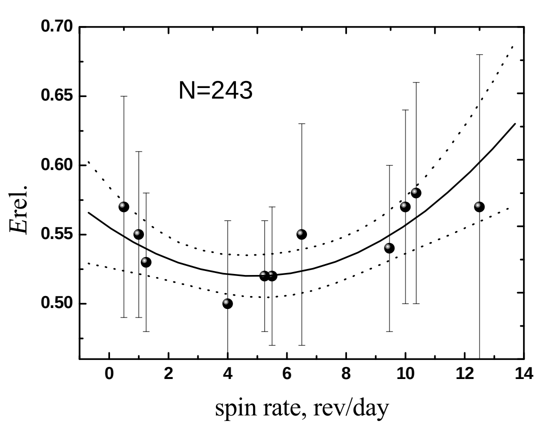

Fig. 3. Correlation of the relative insolations of NEAs and their axis rotation rates.

Fig. 3 shows obtained correlation of axis rotation rates of NEAs and relative values of their insolation. One can see that asteroids of both excesses are in the orbits where they receive about 10% of solar energy more than in orbits of NEAs which are in the middle of the distribution. Obtained correlation is less confident as one in Fig. 2, but it qualitatively agrees well with the character of possible influence of YORP-effect and can be considered as another independent argument in favour of it.

Resume: In this work it is made an attempt to estimate statistically the YORP-effect influence on axis rotation of NEAs. As a result the new data which qualitatively confirm an influence of solar radiation on axis rotation of NEAs are obtained. The novelty of the obtained results is that in contrast to available estimates of YORP-effect influence on axis rotation of the four particular NEAs, it is shown (also on basis of observation data) the influence of the YORP-effect on the distribution of NEA rotation rates, that is, on axis rotation of the whole population of NEAs.

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