Report of Reviewer

Title of PhD thesis: **Yarkovsky and YORP Effects in Dynamics of Small Bodies of the Solar System. Doctoral Thesis**
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In his thesis, the applicant, Mgr. Jindřich Žižka, studied the influence of the non-gravitational perturbations induced by the Yarkovsky and YORP effects as well as solar radiation pressure on the orbital evolution of selected asteroids, asteroid families, and asteroid pairs. The thesis is appropriately divided in four chapters. A description of the theory on the Yarkovsky and YORP effects is given in the first chapter. In the second chapter, the applicant dealt with the non-gravitational perturbations influencing the motion of asteroid (99942) Apophis. The influence of these effects on young asteroid families and pairs is analyzed in the third chapter and an extremely young asteroid pair is studied in the last chapter. An outline of concerning history is added in the appendix.

A prevailing part of the study has already been published by the applicant in three papers in the peer-reviewed scientific journals. In addition, the applicant published four other papers related to the topic.

It is generally well-known that the potentially hazardous asteroid (99942) Aphophis will closely approach the Earth soon, in 2029, and again in 2036 as well as several times later in this century. The probability of its collision with our planet at the approach in 2036 is currently estimated to be non-zero. A consideration of fine effects, like those studied by the applicant, might result in a more precise prediction of the asteroid's motion and, thus, in a refinement of the collisional probability in the post-2029 approaches.

Besides the exceptional case of Apophis, the studied non-gravitational effects are important in changing the orbits of main-belt asteroids to the those crossing the orbits of terrestrial planets. Many of them become the potentially hazardous objects as Apophis. It is worth to know the non-gravitational effects in detail. All this implies that the theme of the dissertation is highly topical.

I did not found any serious weak point in the dissertation. (Few minor imperfections are mentioned below, where I ask to clarify them.) All explanations of phenomena, procedures, methods, and derivations of formulas are clear. The applicant used the standard, currently most advanced methods in the field. The standard method of the age determination of asteroid pair is suitably modified to be efficient also in a weakly convergent case. I appreciate that the applicant did not avoid some problematic points, which occurred in course to find a unique conclusion, and carefully discussed them. Further, I was surprised by a large number of partial problems solved in the dissertation.

Within the dissertation, the applicant achieved several original results. Besides other, it was demonstrated that the solar radiation pressure causes two orders of magnitude smaller shift of a trajectory than the Yarkovsky effect; seven young pairs were discovered, whereby it was noticed that the components of these pairs have the similar size in a contradiction with the current theory of pair formation; it was predicted (and later actually confirmed by other authors) that the asteroid (54827) 2001 NQ8, which is the secondary in pair (6070) Rheinland − (54827) 2001 NQ8, exhibits the retrograde rotation; using the newly modified method of the determination of the age of asteroid pair, the applicant showed that pair (87887) 2000 SS286 − (415992) 2002 AT49 is most probably the youngest known asteroid pair with the age of only about 7.4 kyr, etc. Taking all the results and the way how these were achieved into account, one can conclude that the dissertation is a masterpiece.

I ask the applicant to more clarify the following minor issues, at the defence of the dissertation:

(1) On page 29, in the last sentence of the first paragraph, it is claimed that "The Yarkovsky effect then not only increases the number of NEAs but also maintains the flux of meteoroids to the collision course with Earth." It should be explained in a more detail what "flux of meteoroids" is mentioned here. Namely, there are several sources of meteoroid particles. A prevailing majority of the meteoroids hitting the Earth originate from the cometary nuclei. Among the meteoroids originating from asteroids, not only those released from the surfaces of NEAs can occur in a vicinity of our planet. The non-gravitational effects can likely sufficiently reduce the perihelia of particles released from the main-belt asteroids.

(2) On page 47, in the caption of Figure 2.3, it is said that the closest approach is expressed in Earth's diameters, whereby symbol $R_\oplus$ is used to denote this quantity. Did the applicant intend to say "Earth's radii" (instead "Earth's diameters")?

(3) On page 68, relation (2.45) as well as elsewhere, there is considered the Lagrange equation, in the Gauss form, giving the time evolution of the semi-major axis. The orbit of an object can, however, approach the Earth's orbit closer, when others positional orbital elements are changed. Why the change of other elements is not considered? Can the applicant outline a reason of why the Yarkovsky effect does not change (or changes negligibly) the other elements?

At the end, I would like to point out two minor imperfections (I do not ask the applicant to give any response to these points; I simply state them):

(a) On page 6, in the last line of the third last paragraph, the obsolete official name, 1882 II, of the Great Comet of 1882 is given. Instead, the current denotation of the comet should be given (C/1882 R1).

(b) On page 34, in the 8-th line, the distribution of $(a_p,\ H)$ is mentioned. For a more confortable reading, it would be useful to mention, already in an adjacent part of the text, what is quantity H.

The quality of the formal elaboration of the dissertation is very high and the above, extemely short list of imperfections evidences this fact. I note, it is the shortest such list I have ever found in the referred dissertations.

In his dissertation, the applicant, Mgr. Jundřich Žižka, demostrated a high abbility for an independent and excellent scientific work. I recommend to the Faculty of Mathematics and Physics of the Charles University to grant him the academic degree *Philosophiae Doctor*, Ph.D.

In Tatranská Lomnica, on August 14-th, 2018.

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