Belgrade, 17 February 2020

Report on the doctoral thesis entitled "Identification methods of genetically related asteroids" by Mr. Petr Fatka.

Groups of genetically related asteroids generally form in two ways: by collisional disruption and by disruption due to the rotational fission. In principle, asteroid clusters formed by rotational fission and asteroid families created by catastrophic collisions can by distinguished by comparing relative velocities of their members at the moment when the system became unbound. Recently, it has been proposed that members of young collisionally formed clusters are more likely to be subjects of rotationally induced fragmentation. Moreover, separation of secondaries from a primary body, may happen more than once, and at different times. Each of these scenarios lead to the concept of the *cascade disruption*. In this respect, the work presented by Mr Fatka is among pioneering steps to investigate this phenomenon, and is definitely the most comprehensive study along these lines so far. The subject of the thesis is not just currently a hot topic in asteroid-related science, but it is relevant in more general context, and may help us understanding better the evolutionary process acting on asteroids. These include better understanding of the YORP cycle time-scale, asteroids' internal structures, their size-frequency distribution, and some other related problems. For instance, a possible difference between observed properties of C/C-like and S/S-like asteroid pairs would be very interesting to find, as it could provide an information on how their different material properties affect the asteroid fission process.

The thesis presents a broad approach to the subject, proving that the author successfully joins knowledge and abilities from various fields and research areas such as celestial mechanics, numerical simulations, and observations and data analysis. The thesis is well-organized, covers all relevant subjects, and the text is written in clear and concise manner. In the first chapter Mr. Fatka gives an overview on asteroid population and main orbital and physical characteristics of asteroids. In particular, different types of orbital elements as well as Yarkovsky and YORP thermal effects are described. Finally, a nice brief summary about possible formation mechanisms of asteroid pairs and clusters is given. In the second chapter, the author is explaining one of the most important aspect of this study, methods for the identification of asteroid pairs and clusters. It includes methods for estimation of the statistical significance of newly discovered clusters, details on backward integration method, and age estimation methodology. The third chapter presents the main results of Mr. Fatka's thesis. The fourth chapter summarizes the main findings and conclusions resulting from the thesis. Finally, the bibliography contains a respective list of over 80 appropriate references.

The work done by Mr. Fatka is impressive, and includes both, theoretical and observational aspect. Detailed numerical analysis and reconstruction of past orbital motion of asteroid pairs and clusters reveled their separation times and corresponding relative velocities, which in turn pointed out formation mechanisms of these pairs and clusters. The results disclosed commonality of cascade disruptions and the major role of the rotational fission. The work also includes photometric study of a sample of nearly 100 asteroid pairs, that enlarged the sample of studied asteroid pairs by a factor of ~3, and also went to smaller asteroid sizes than before. This allowed seeing new features in the asteroid pair population.

I would have the following suggestions for the thesis defense discussion:

1. Sizes of asteroids studied in this thesis are typically small, as are consequently also their masses. However, the close encounters considered to be relevant are typically within a few Hill radii. Should we expect that neglected masses of asteroids may influence the obtained results regarding the minimum distances, relative velocities and separation times in asteroid pairs?

2. Section 2.2.1, page 22: To account for the Yarkovsky effect, author created three Yarkovsky clones for each asteroid and assigned them with zero, the maximum negative and the maximum positive Yarkovsky acceleration. This approach is acceptable, but it assumes that YORP effect have had enough time to push the asteroid's obliquity towards one of the extreme values. As at least some components of the asteroids pairs (clusters) seem to be young enough to expect a somewhat wider obliquity distribution, I'm wondering would it be worthwhile for the future work to improve the results by considering more Yarko clones?

3. Table 3.4, page 37: It would be interesting to check is there any relation between sizes of secondaries and their distances from the primary? Given that separation should occur approximately at escape velocity, and taking into account that the escape velocity from the primary is largest at the beginning of the cascade disruption, shouldn't we expect correlation among the separation distances and times?

4. Equation 3.2, page 26: The mass ratio between a primary and a secondary is based on the difference between their absolute magnitudes. This assumes not only the same surface reflectance characteristics of these objects, but also the same density. To what extend is this assumption expected to be valid?

Overall, the thesis presents very interesting new results, which are described in a very clear and readable way, and the scientific contribution of the author and his thesis is significant. Publications in peer-reviewed journals speak for themselves: in one case Mr. Fatka is the first author, and in the other three cases he is the second author. Mr. Fatka is among the key contributors for each of these papers. In conclusion, I have no doubt that this thesis proves the author ability for creative scientific work, and recommend granting Mr. Fatka the PhD degree.

Sincerely,

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