Supervisor’s review of doctoral thesis

Asteroid Models from Sparse Photometry

submitted by Mgr. Josef Hanuš

The submitted manuscript is an outcome a four-year doctoral study of J. Hanuš. The topic of his research was the use of the lightcurve inversion method on asteroid sparse-in-time photometry. The aim of that was to derive more asteroid models and to reveal new interesting properties of the asteroid population. This aim was reached – the number of new asteroid models derived in this work was about 300, which significantly enlarged the previous sample of about hundred models. Based on this enlarged sample, Mr. Hanuš revealed an interesting distribution of orientation of spin axes of small asteroids. The distribution is strongly anisotropic with pole directions avoiding the plane of the ecliptic. This observational fact can be naturally explained by the long-term evolution of spins due to the YORP effect. From my point of view, this is the main scientific result of the Thesis. It also shows the general fact that by modelling physical properties of individual objects, we can reveal physical processes acting on the whole population of small bodies in the solar system.

In his manuscript, Mr. Hanuš clearly describes his work in a logical and detailed way. After explaining why asteroid models are important for solar system science, he describes the lightcurve inversion method and its practical implementation he used. Then he moves on to sparse photometry, its reduction, estimation of errors etc. An important part of the Thesis addresses the problem of testing the reliability of models that were derived from sparse data. This will become particularly important when more sparse photometry will be available from big surveys and we move from hundreds of models to tens thousands of them. Then the whole processing pipeline will have to be fully automated with very low probability of producing wrong models.

The core of the Thesis consists of two chapters where the parameters of all derived models are listed and the distribution of spin axes is discussed. To be sure that the features in the observed distribution are real, the author removes the bias caused by the lightcurve inversion method. The clustering of pole directions towards poles of the ecliptic can be explained by the YORP effect. A theoretical model of the spin evolution is presented and compared with the data. Another display of the YORP effect is the distribution of spin axes of members of asteroid families. This is demonstrated on four asteroid families and the observed pole distribution agrees with theoretical expectations.

In the last part, the author makes use of available adaptive optics images of asteroids and compares them with plane-of-the-sky projections of asteroid models. By this, he scales models of about 40 asteroids and also solves the pole ambiguity for about ten of them.

During his work, Josef Hanuš mastered various aspects of scientific work – from communication with tens of backyard observers who provided the data, to automatic processing of data from astrometric surveys for hundreds thousands asteroids. He presented his results on several international conferences and most of the content of this manuscript was already
published in peer-reviewed journals. Given the original results he achieved and the clear and critical way he presents them, I fully recommend to accept this work as PhD Thesis.

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Josef Šírůch