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Shapes and spin states of asteroids derived from the Lowell photometric database

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1. Introduction

Asteroid shapes and spin states can be derived from their disk-integrated photometry by the lightcurve inversion method [1]. This method can be used to a set of classical lightcurves as well as to photometric data that are sparse in time with respect to the rotation period. Sparse-in-time data provided by current all-sky surveys are spoiled by large random and systematic errors. However, they are available for essentially every known asteroid.

2. Lowell photometric database

The database consists of re-calibrated photometry for about 500,000 asteroids, typically hundreds of brightness measurements per asteroid. This database was created by [4], they partly removed the most prominent systematic trends in the photometry reported to Minor Planet Center. The typical accuracy of the data is around 0.2 mag.

With huge amount of photometric data, the lightcurve inversion becomes a computationaly demanding process. Because the data are sparse in time, the rotation period – the basic physical parameter – cannot be estimated from the data easily. Contrary to classical lightcurves where the period is "visible" in the data, a wide interval of all possible periods has to be scanned densely when analysing sparse data. This fact enormously enlarges the computational time and the only practical way to efficiently handle photometry of hundreds of thousands of asteroids is to use distributed computing. Moreover, the problem is ideal for parallelization – the period interval can be divided into smaller parts that are searched separately and then the results are joined together.

3. Asteroids@home

Asteroids@home (http://asteroidsathome.net) is a volunteer-computing project that uses an open-source BOINC (Berkeley Open Infrastructure for Network Computing) software to distribute tasks to volunteers, who provide their computational resources. The project was created at the Astronomical Institute, Charles University in Prague, in cooperation with the Czech National Team. The scientific aim of the project is to solve a time-consuming inverse problem of shape reconstruction of asteroids from sparse-in-time photometry. The nature of the problem makes it an ideal task to be solved by distributed computing – the period parameter space can be divided into small bins that can be scanned separately and then joined together to give the globally best solution.

Users install the BOINC client and set up the preferences. The tasks are then automatically downloaded, computed, and the results are uploaded to the server. Each user scans a small part of the parameter space. The whole period interval (typically 2–100 hours) is divided into several hundreds of workunits that are distributed to users.

The results sent by users are validated by comparing the same tasks computed by two different users. If the results are different, the workunit is sent to other users until an agreement is reached. The results are stored in the database and are accesible via a web interface.

4. Results

We have been processing Lowell photometric data in the framework of Asteroids@home. From tens of thousands asteroids processed so far, we have been able to reconstruct new unique models for hundreds of asteroids. These new models significantly enlarge the sample of asteroids with known orientation of the spin axis. By this enlarged sample, we will improve the statistics of the distribution of asteroid spin axes.

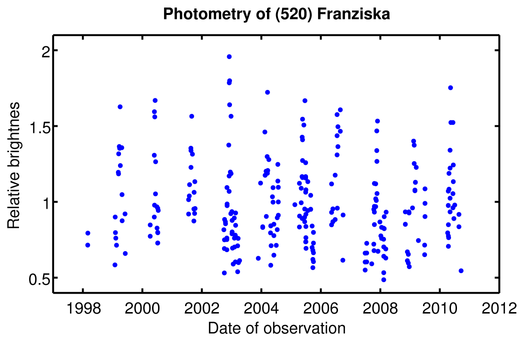

Figure 1: Lowell sparse photometry for asteroid (520) Franziska. The brightness was reduced to a unit distance from the Sun and the Earth.

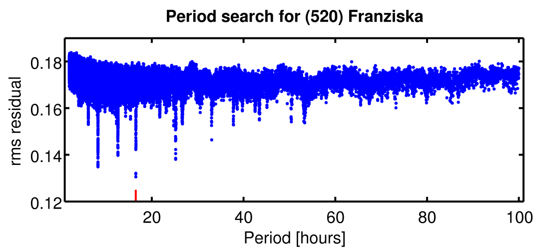

Figure 2: Period scan for asteroid (520) Franziska. The best-fit period is 16.50442 h (the lowest RMS resudual between the data and the model).

The first results, based on models derived from combined dense and sparse photometry, were published in [2] and [3].

An example of a typical Lowel photometric data set is shown in Fig. 1. The data for asteroid (520) Franziska consist of 384 individual brightness points covering an interval of about 12 years. The period scan for this asteroid is shown in Fig. 2. The RMS of the fit between the model and the data is plotted against the testing periods between 2 and 100 hours. The best-fit period is 16.50442 h. The second lowest minimum corresponds to the half period of 8.25 h. However, shape models corresponding to this period are unphysical. The two convex models of (520) Franziska derived from Lowell photometry are shown in Fig. 3.

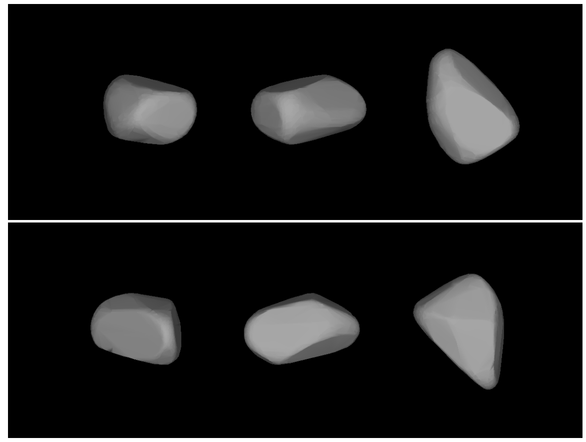

Figure 3: Two models of asteroid (520) Franziska seen from equator (left, center) and pole-on (right). The corresponding directions of the spin axis in ecliptic longitude and latitude are $(120°, -47°)$ (top model) and $(298°, -67°)$ (bottom model).

Acknowledgements

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References

[1] Kaasalainen, M., Torppa, J., Muinonen, K.: Optimization Methods for Asteroid Lightcurve Inversion. II. The Complete Inverse Problem. Icarus 153, 37-51, 2001.

[2] Hanuš, J., and 13 colleagues: An anisotropic distribution of spin vectors in asteroid families. Astronomy and Astrophysics 559, A134, 2013.

[3] Hanuš, J., and 119 colleagues: Asteroids' physical models from combined dense and sparse photometry and scaling of the YORP effect by the observed obliquity distribution. Astronomy and Astrophysics 551, A67, 2013.

[4] Oszkiewicz, D. A., Muinonen, K., Bowell, E., et al.: Online multi-parameter phase-curve fitting and application to a large corpus of asteroid photometric data. Journal of Quantitative Spectroscopy and Radiative Transfer 112, 1919-1929, 2011.