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The ambiguities in the asteroid spin determinations – statistical analysis

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Abstract

Asteroid rotation periods are most often derived from their brightness variations. Excluding binary systems and objects with a non-principal axis rotation, the rotation period is usually identical to the period of the second Fourier harmonic of the lightcurve. There are cases, however, where it is connected with the 1st, 3rd or 4th harmonic. We simulated the light variation of asteroids with shapes modelled as Gaussian random spheres to check in which circumstances a simple "two maxima, two minima per period" assumption becomes invalid. Results can help in interpreting real data, which are often noisy and/or do not cover the whole rotation of the asteroid.

1. Introduction

Rotation of small asteroids evolves due to YORP, close planetary encounters and mutual collisions. Spin changes can lead to mass shedding, binary formation and rotational fission. There is a central database of asteroid rotation periods, LCDB [3], which assigns a reliability code to each spin. For many small asteroids rotation periods, derived from their light variations, are ambigious due to the noisy data and/or incomplete rotation coverage. In the present paper we analyze the simulated asteroid lightcurves to check how often, for typical shapes of asteroids and geometries of observation, bimodal lightcurves occur.

2. Method

Shapes of asteroids were modelled as Gaussian random spheres (lognormal statistics) described by [1] and [2]. A combination of Lommel–Seeliger and Lambert scattering laws was assumed in those numerical calculations.

For each shape we randomly selected 1000 positions of the spin axis, systematically changing the solar phase angle with a step of 5°in the interval from 0°to 70°. The total number of simulated lightcurves was 1 400 000. Fig. 1 presents two examples of the lightcurves obtained during our simulations (brightness variation versus the angle of rotation).

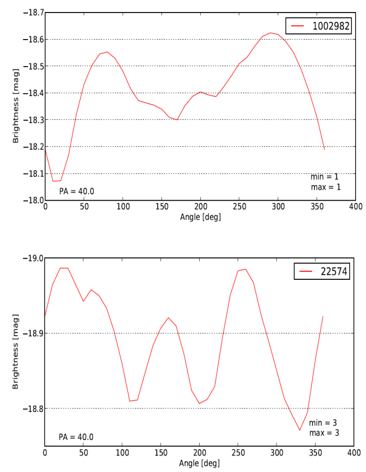

Figure 1: Examples of the simulated asteroids' lightcurves. Number of extrema (right-bottom corner) and value of a phase angle (left-bottom corner) are given.

3. Summary and Conclusions

For each lightcurve we determined its peak-to-peak amplitude, fitted the 4th order Fourier series and derived the amplitudes of its harmonics. Instead of the number of lightcurve extrema, which in many cases is subjective, we characterized each lightcurve by the order of the highest amplitude Fourier harmonic. Results are shown in a tabular form in Fig. 2. Each table presents, for a specified range of phase angles and peak-to-peak amplitudes, the percentage P of simulated lightcurves with a dominant harmonic N. Empty

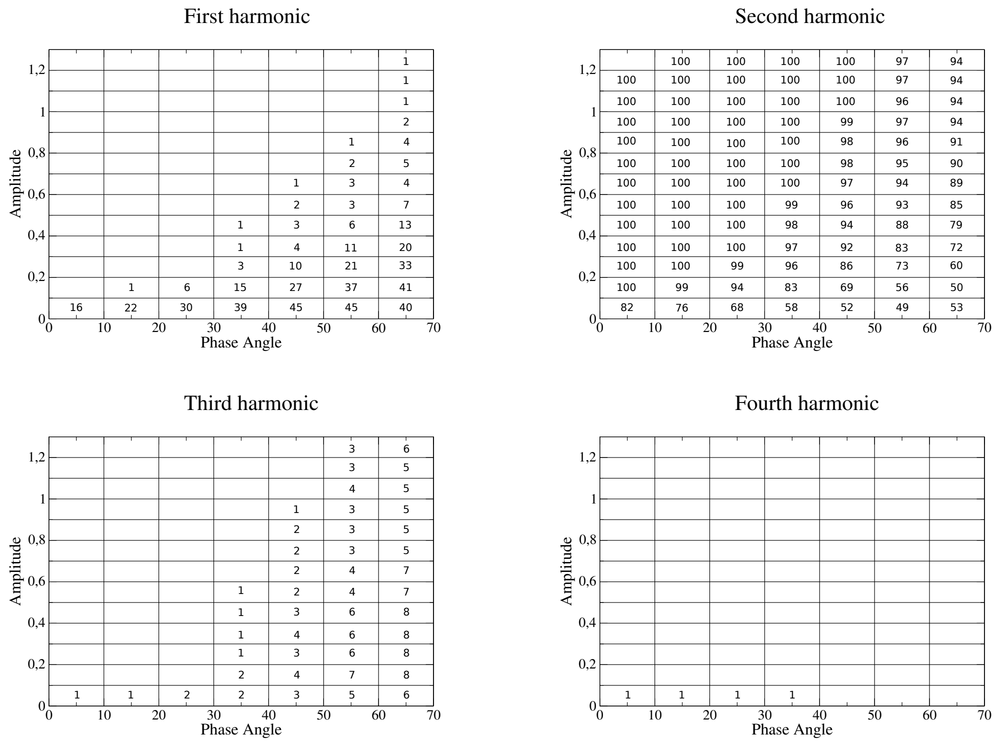

Figure 2: Table presenting a percentage distribution of lightcurves with a dominant 1st, 2nd, 3rd and 4th Fourier harmonic, respectively. Each bin contains results derived from thousands of lightcurves.

bins correspond to P<1%.

For practical purposes we can assume that the most typical "two maxima, two minima per period" interpretation of light variations becomes uncertain when the fraction of the lightcurves with the dominant 2nd harmonic becomes less than 90%. Fig. 2 shows that for Main Belt Asteroids, observed at phase angles PA smaller than 30°, such situation happens when the lightcurve amplitude is smaller than 0.1 mag. Such lightcurves are often noisy and it may not be easy to check if there is one or two maxima per asteroid rotation.

For near-Earth asteroids ambiguities arise not only at small lightcurve amplitudes, but also at higher phase angles. When planning the observations of those objects it may be advantageous to limit them to PA<40°. In such cases when the observed lightcurve amplitude is >0.2 mag we can assume the period to be equal to the period of the 2nd Fourier harmonic.

Other applications of the presented results will be shown during the conference.

Acknowledgements

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References

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