Statistical analysis of the ambiguities in the asteroid period determinations

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A synodic period of an asteroid can be derived from its lightcurve by standard methods like Fourier-series fitting. A problem appears when results of observations are based on less than a full coverage of a lightcurve and/or high level of noise. Also, long gaps between individual lightcurves create an ambiguity in the cycle count which leads to aliases. Excluding binary systems and objects with 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 may be connected with the 1st, 3rd, or 4th harmonic and it is difficult to choose among them when searching for the period. To help remove such uncertainties we analysed asteroid lightcurves for a range of shapes and observing/illuminating geometries. We simulated them using a modified internal code from the ISAM service (Marciniak et al. 2012, A&A 545, A131). In our computations, shapes of asteroids were modeled as Gaussian random spheres (Muinonen 1998, A&A, 332, 1087). A combination of Lommel–Seeliger and Lambert scattering laws was assumed. For each of the 100 shapes, we randomly selected 1000 positions of the spin axis, systematically changing the solar phase angle with a step of 5°. For each lightcurve, we determined its peak-to-peak amplitude, fitted the 6th-order Fourier series and derived the amplitudes of its harmonics. Instead of the number of the lightcurve extrema, which in many cases is subjective, we characterized each lightcurve by the order of the highest-amplitude Fourier harmonic. The goal of our simulations was to derive statistically significant conclusions (based on the underlying assumptions) about the dominance of different harmonics in the lightcurves of the specified amplitude and phase angle. The results, presented in the Figure, can be used in individual cases to estimate the probability that the obtained lightcurve is dominated by a specified Fourier harmonic.

Some of the conclusions are: (1) the 4th harmonic dominates about 1 percent of lightcurves only at low amplitudes ($A < 0.1$ mag, $\alpha < 40°$). (2) The dominance of the 3rd harmonic can be observed more often only in the case of near-Earth asteroids, observed at $\alpha > 30°$; for the main-belt asteroids (MBAs), it can be present only in small amplitude lightcurves ($A < 0.1$ mag). (3) The 1st harmonic is present quite often in the low-amplitude ($A < 0.2$ mag) lightcurves of MBAs; for NEAs it can be seen even in high-amplitude lightcurves ($A < 0.7$ mag for $\alpha \simeq 40°$, $A < 0.9$ mag for $\alpha \simeq 50°$). (4) In 100 percent of the cases, the 2nd harmonic dominates the lightcurves of MBAs whose amplitudes $A > 0.2$ mag.

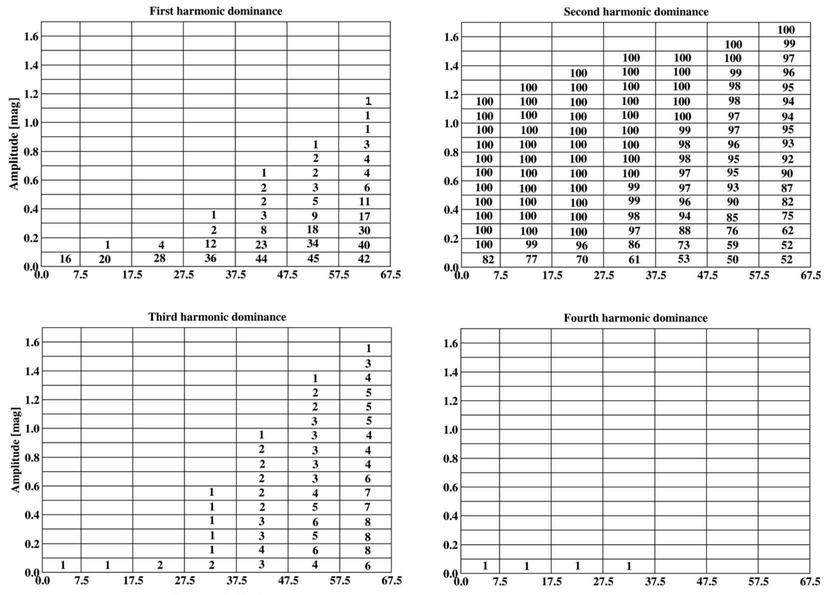

Figure: Fraction of lightcurves (in percent) in which the specified Fourier harmonic is the greatest. Empty bins refer to lower than 1 % occurrence.

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