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Asteroid spin-axis longitudes from the Lowell Observatory database

E. Bowell (1), D. A. Oszkiewicz (1,2,3), L. Wasserman (1), **K. Muinonen** (1,4), A. Penttilä (2), D. Trilling (3)
(1) Lowell Observatory, USA (2) University of Helsinki, Finland (karri.muinonen@helsinki.fi) (3) Northern Arizona University, USA (4) Finnish Geodetic Institute, Finland.

Abstract

Using the Lowell Observatory photometric database, we analyze the variation of reduced magnitudes with ecliptic longitude, thereby estimating spin-axis longitudes for hundred of thousands of asteroids. Hitherto, spin-axis longitude estimates have been made for fewer then two hundred asteroids. We investigate longitude distributions in different dynamical groups and longitude preferences in asteroid families. We show that asteroid spin-axis longitudes are not isotropically distributed, as has been suggested by some theoretical studies. For the main belt as a whole, we find a marked depletion of spin-axis longitudes near 140° and excesses near 30° and 90°. For Jupiter Trojans there is preponderance of spin axes near 100°. We describe longitude distributions for asteroid families.

1. Methods

We have found clear evidence for longitude variation of the mean absolute brightness of the majority asteroids (an example is given in Fig. 1). In the absence of surface albedo features, it can be assumed that the peak absolute brightness occurs at minimum polar aspect angle; that is, when an asteroid's spin axis is most nearly pointing toward or away from Earth. We fit a sinusoid to reduced magnitude variations as shown in Fig. 1, and find the spin-axis longitude at the maximum of the curve. The fitted curve is:

$$a + b\sin[2\alpha + c], \qquad (1)$$

where phase c, amplitude b, and origin point a are fitted simultaneously using least squares and α is the heliocentric ecliptic longitude. We estimate the spin-axis longitudes of hundreds of thousands of asteroids, creating the biggest list of asteroid spin-axis longitudes currently known (by comparison the Poznań Observatory database [1] comprises fewer than two hundred rotational pole solutions). In Fig. 2, we plot spin-axis longitudes based on heliocentric longitude brightness variation (Lowell Observatory database) versus spin-axis longitudes from the Poznań Observatory database [1]. There is good agreement between results from the new method and estimates by others. There are some discrepancies near 0° and 180° because some asteroids in the Poznań database contain spin estimates from authors who do not always agree with each other.

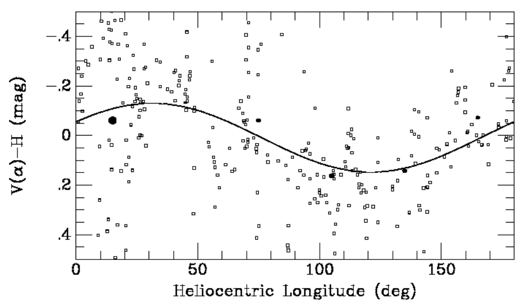

Figure 1: Brightness variation with heliocentric longitude (mod 180°) for (93) Minerva. The sine curve fit indicates a spin-axis longitude of 30° (or a symmetric solution of 210°).

Our spin-axis longitude estimates can help constrain the phase-space of possible asteroid spin and shape solutions in lightcurve inversion methods, especially in cases where the parameter phase-space has many local minima.

2. Results

The main findings concern MBOs and NEOs. Fig. 3 shows the distribution of spin-axis longitudes for MBAs (blue) and NEAs (green). It has previously been suggested that the NEA pole longitude distribution exhibits two sharp maxima [1], but the finding was uncertain because of the low contrast of the maxima compared to the mean background. In Fig. 3, the

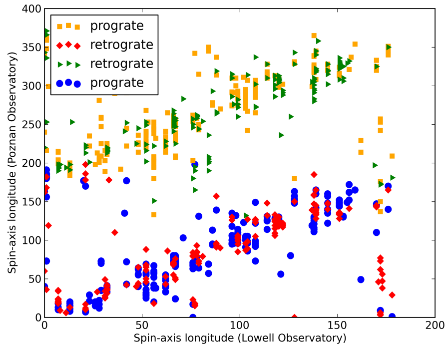

Figure 2: Comparison of estimated spin-axis longitudes derived from longitude brightness variation (Lowell Observatory) and other methods (Poznań Observatory).

NEA distribution appears to be random, and we also cannot confirm any significant spikes. The longitude

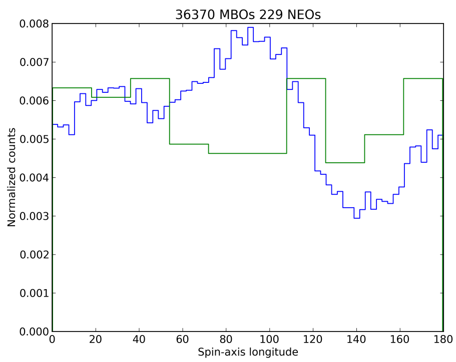

Figure 3: Distribution of spin-axis longitudes for MBOs and NEOs.

distribution for MBAs shows three distinct features: two maxima (around $30°$ and $90°$) and a minimum (around $140°$). Anisotropy of spin-axis longitudes has already been suggested by La Spina [2] and Samarashina [3]. We can confirm that the longitude distribution for MBAs is far from uniform, with a paucity at $120-180°$, as already suggested ([2] [3]). That conclusion is, however contrary to Hanus et al. [4], who found that the longitude distribution for MBAs shows no significant features and is very close to uniform, with the exception of asteroids smaller than 30 km diameter. The smaller asteroids showed a slight excess of small spin-axis longitudes, but it was assumed to be just a random coincidence rather than a result of some physical process. Also Kryszczyńska et al. [1] concluded that dips in the longitude distributions in the regions $120-180°$ and $300-360°$ are only of about "$1-\sigma$" significance and cannot be confirmed. However, the number of objects used in the previous studies was significantly smaller (about 200 objects), than what we used in our study (about $40,000$ objects). The local maximum of the MBA distribution at $30°$ is likely due to asteroids being trapped in the ν_6 secular spin-orbit resonance, as has been explained for Koronis family members [5]. The secondary maximum at $100°$ remains of unknown origin. However, a similar peak around $100°$ longitude can be seen in La Spina's histograms [2].

Acknowledgements

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References

[1] A. Kryszczyńska et al. New findings on asteroid spin-vector distributions, *Icarus* **192**, 223-237 (2007).

[2] A. La Spina et al. Distribution of spin vectors: Differences between main belt and near-Earth asteroids longitudes, *Planetary Science: Fifth Italian Meeting* proceedings, Gallipoli (2003).

[3] N. H. Samarashina and T. Karr Orientation of asteroidal spin vectors, *Bull. Am. Astron. Soc* **30**, 1035 (1998).

[4] J. Hanus et al. A study of asteroid pole-latitude distribution based on an extended set of shape models derived by the lightcurve inversion method, *A&A* **arXiv:1104.4114v1 [astro-ph.EP]**, (2011).

[5] D. Vokrouhlický, D. Nesvorný, W. F. Bottke The vector aligments of asteroid spins by thermal torques, *Nature* **425**, 147-151 (2003).