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Spin Axis Pole Distribution of the Hungaria Asteroids: An Initial Look

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Abstract

The Hungaria asteroids are small (D < 13 km) inner main belt objects with high orbital inclinations (16-34°). As such they are not subject to planetary tidal encounters and so serve as a control group for the development of theories on binary population, spin axis rate distributions, etc. involving the near-Earth asteroid population (see Warner *et al.* [6]). Our previous work based on the acquisition and analysis of *dense* lightcurves helped establish that the spin axis rate distribution of the Hungarias is similar to the NEA population, including a strong excess of slow rotators (P > 24 h), and that the percentage of binary asteroids within the two groups is also similar. Our efforts have now turned to looking at the spin axis pole distribution of the Hungarias, e.g., to determine if that distribution is isotropic or, as Slivan [5] found for the Koronis family, there are distinct "clumps" or trends within the distribution. We report on our initial analysis that is based on the combination of *dense* and *sparse* lightcurve data (see Durech *et al.* [1] for a discussion regarding the differences between dense and sparse data sets). So far, our analysis is inconclusive due to the fact that there are too few Hungarias with sufficient lightcurve data to determine reliable pole solutions. We conclude by discussing the reasons why this is the case and our plans to overcome this deficiency.

1. Introduction

The Hungaria asteroids are mid- to high-albedo objects on the inner edges of the main belt with high orbital inclinations (1.8 < a < 2.0 AU; 16° < i < 34°). We have concentrated our efforts the past few years on acquiring dense lightcurves and subsequent analysis of this intriguing group/family (see Warner *et al.* [6], Milani *et al.* [4], and McEachern *et al.* [3]) that may provide many insights into solar system dynamics of orbital evolution and resonances, binary formation, spin axis rates, and the causes of an excess of slow rotation and tumbling, many of which may be due to thermal torques such as the Yarkovsky and YORP effects.

Now that at least one dense lightcurve has been obtained for some 200 Hungaria asteroids during one or more apparitions, we have begun work on using lightcurve inversion techniques (Durech *et al.* [1] and references therein) to determine the distribution of spin axis poles within this group/family. Among the many possibilities that we want to explore is if the distribution is isotropic or anisotropic. If the latter, we would then ask if there a "clumping" of poles or a bias toward given ecliptic latitudes and/or longitudes?

2. Initial Results

In our analysis, we use the available dense and sparse lightcurve data to find a probable period, with the periods derived from the dense lightcurves alone serving as a starting point and indicator of the likely search range. Once a period is found, we then generate 264 different models using fixed, discrete longitude-latitude pairs, but allowing the period to float slightly. The log(chi-square) values are then plotted to give a visual indication of the overall quality of the solution. Hanuš and Ďurech [2] give a set of analytical rules to determine which, if any, period and subsequent pole solution can be considered reliable.

Figures 1 and 2 show examples of the plot of the log(chi-square) values. In them, dark blue represents the lowest chi-square value while deep red (maroon) represents the highest value. The log(chi-square) values are used to expand the mid-range values and compress the extremes so that both the "best" and "worst" solutions stand out more clearly. Figure 1 shows a "good" solution in that there are two small regions of blue (indicating the common possibility of both a retrograde and prograde solution). Figure 2, on other hand, shows the result of not having sufficient data to determine a good period and/or pole solution. It is almost entirely shades of blue, indicating that –

save for a few obvious longitude-latitude pairs – almost any solution is as good as any other.

The reason for the bad solution (which is far more common than a good solution) is simply that there are not yet enough data available. While data from current astrometric surveys (e.g., Catalina Sky Survey, LONEOS, and USNO-Flagstaff) have provided sparse data that helped generate a number of good pole solutions, their data sets are limited when it comes to the Hungarias. This is because they have concentrated their work along the ecliptic. Due to their high orbital inclinations, the Hungarias are often well off the ecliptic and away from survey coverage.

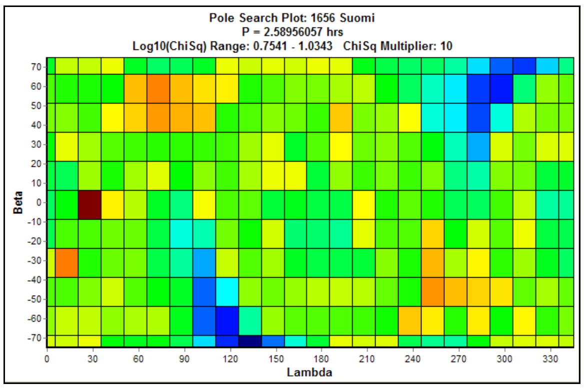

Figure 1. An example of a good pole solution.

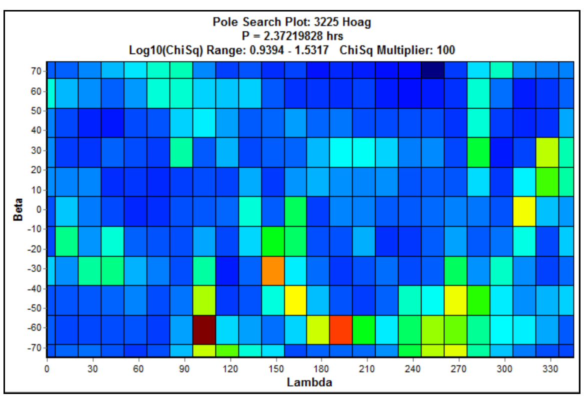

Figure 2. An example of a bad pole solution.

3. Summary and Conclusions

Future wide-field surveys, if/when they come on line, will take up to a decade to accumulate sufficient sparse data to make a significant contribution to determining Hungaria poles. In the meantime, the best solution lies with continued efforts such as ours that accumulate dense lightcurves and more so, concentrate on those objects for which there are dense lightcurves available in order to help assure a more reliable solution for each asteroid in the shortest time possible.

Acknowledgements

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