Resolving Ambiguities in Shape and Pole Models of 832 Karin

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Abstract

The Karin family is a main-belt family of newborn asteroids, resulting from a collision 5.8 ±0.2 Myr ago. The dynamically young age of the Karin family makes it an ideal candidate for study of the timescales of several post-formational processes, including YORP thermal effects. As the presumed parent body of the Karin family, 832 Karin is especially of interest in the study. Currently, the asteroid 832 Karin has two possible pole/shape solutions, as generated from lightcurve inversions. This project combined data obtained by the Table Mountain Observatory Near-Earth Object Photometry team over the summer of 2012 with archived ground-based observational data dating back twenty-five years in order to assist in the resolution of these pole and shape ambiguities. Using software from the DAMIT (Database of Asteroid Models from Inversion Techniques) website and the amassed observational data, new shape models were constructed using disk-integrated lightcurve inversion techniques. At this point in time, it looks likely that 832 Karin will require further ground-based observations during future apparitions in order to fully resolve the shape and pole ambiguities, however the models will further contribute to the archived data to identify possible YORP thermal effects in spin-state evolution.

1 Introduction

Although over twenty-five years of ground-based observational data have been accrued on the Karin family and its' parent body, 832 Karin, a definite shape/pole model has yet to be determined. The Karin family, or the Karin cluster, is located in the main-belt between Mars and Jupiter. The cluster consists of approximately 90 bodies, embedded within the Koronis asteroid family, and is formally considered a sub-class of the Koronis family. The close proximity of the asteroids requires that careful disk-integration be performed to properly differentiate Karin from Koronis family members. At approximately 19 km in diameter, 832 Karin is the largest, and therefore parent body of the cluster.

The Karin family is one of the most recently developed collisional families. It is estimated that the formational event occurred approximately 5.8 ± 0.2 Myr ago (Nesvorny et al., 2002). The Karin cluster is of particular interest in the astronomical community due to this dynamically young age. The relative youth of the Karin members makes them a prime target for research of collisional dynamics and post-formational processes. The asteroids have been subject to relatively little collisional and dynamical weathering in the time since their formation, and the largest members' orbital evolutions have been modeled extensively (Nesvorny et al., 2002, Nesvorny et al., 2004, Nesvorny et al., 2006b, Vokrouhlicky et al., 2006). The proper orbital elements of the Karin cluster as compared to the main-belt asteroids are presented in Figure 1.

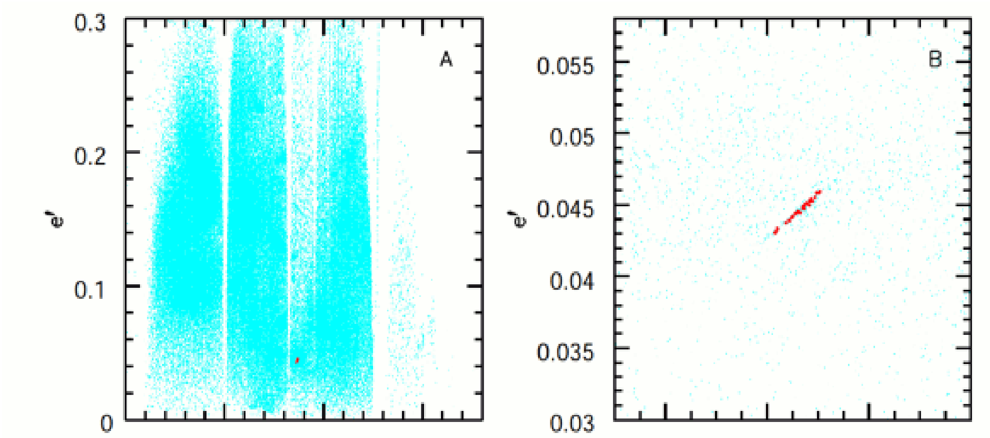

Figure 1. Proper semi-major axis, a', and proper eccentricities, e', of main-belt asteroids (light blue) and Karin family members (red)

Thermal processes, in particular, the Yarkovsky force and the YORP (Yarkovsky-O'Keefe-Radzievski-Paddack) effect are under investigation within the Karin cluster. The YORP effect may be used to explain evolution of spin-state and axial tilt. As the asteroid rotates, the side of the asteroid that is illuminated by the sun in the afternoon and early evening is warmer. That thermal energy causes a force towards the dawn/night side, and causes the object to either spiral inwards towards the sun or outwards away from the sun, depending on its' rotation. The dynamically young age of the Karin family makes it an ideal candidate for post-formational spin-state alteration. The asteroids are relatively intact in their newborn spin-states. The Karin family can serve as a baseline, as observational data accrued over time can provide evidence of these post-formational processes.

The Karin cluster is also an ideal target for collision dynamics research. Because of it's young age, the collisional fragments are better preserved, having been subject to less space-weathering. This provides valuable information in computer modeling of collisional events, specifically as checks for larger-scale modeling. These results may be interpreted on a larger-scale in planetary formation research.

2 Instrumentation

For our research, ground-based observations of 832 Karin were necessary in order to generate our models. The Table Mountain Observatory Near-Earth Object Photometry Team (TMNPT) was able to capture three nights of observational data on June 29, July 20 and July 21, 2012. The Table Mountain facility, located in Wrightwood, California, houses an Astro-Mechanics 0.6 m Ritchey-Chretien reflector telescope, which we utilized for our observations of 832 Karin. Our imaging was performed using a liquid cryostat cooled 2K Spectral Instruments CCD, and data was reduced and analyzed using IRAF (Image Reduction and Analysis Facility) software system.

3 Methods

The 832 Karin observational data obtained by the TMNPT was used to construct a partial lightcurve (Fig 2). Our lightcurve is consistent with observations reported by Sasaki et al. (2004), Yoshida et al. (2004), and Sasaki et al. (2006), and reflects a 18.35 hour rotational period. This lightcurve data and its' corresponding geometries were combined with years of archived data to generate a three-dimensional shape model and pole solution for 832 Karin. These three-dimensional shape models and pole solutions are used to detect thermal processes, particularly the YORP effect (Kaasalainen et al. 2007).

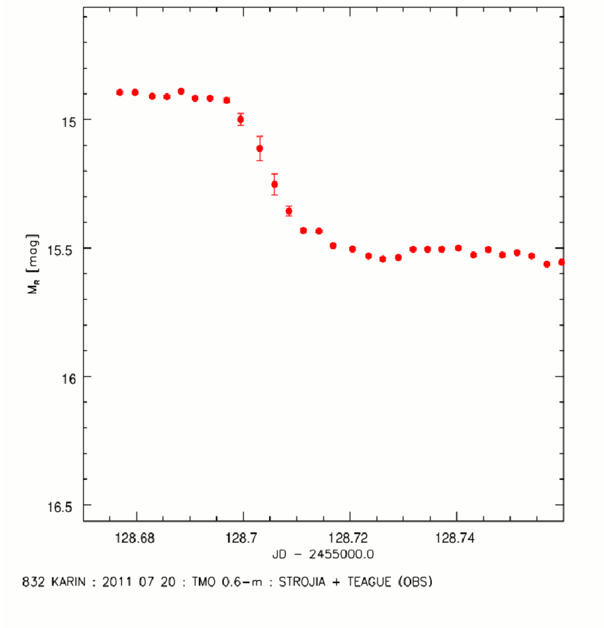

Figure 2: Partial lightcurve of 832 Karin obtained July 20, 2012

The data used to construct our shape model and pole solution was archived within DAMIT (Database of Asteroid Models from Inversion Techniques). Developed in 2010 by Josef Durech (Astronomical Institute of the Charles University, Prague, Czech Republic), Mikko Kaasalainen (Department of Mathematics, Tampere University of Technology, Tampere, Finland), and Vojtech Sidorin (Astronomical Institute of the Academy of Sciences of the Czech Republic, Prague), the database contains archived observational data of 832 Karin dating back to 1984, all of which was used in our modeling.

DAMIT archives lightcurve and geometric data used in three-dimensional shape modeling. DAMIT also stores the shape model, the spin-axis orientation, and the rotational period for the asteroids. The models are generated using lightcurve inversion techniques and are represented by polyhedrons with triangular surface facets. As of August 31, 2012, the database contains 343 models for 209 asteroids. The discrepancy arises when asteroids orbit too close to the ecliptic, causing a 180 degree ambiguity in ecliptic longitude of the pole, and therefore two shape models and pole solutions, or if models are constructed using different inversion methods. 832 Karin is one of these asteroids with ambiguity in the ecliptic longitude of the pole, producing two shape models and pole solutions.

The DAMIT web interface contains a program written by Mikko Kaasalainen and Josef Durech called convexinv that gives a best fit to the lightcurve data for construction of a shape, spin, and scattering model. We input our lightcurve data for 832 Karin, combined with the archived data to create a model. This model is the Gaussian image, which is then input into another Kaasalainen and Durech program, minkowski. Minkowski outputs a convex polyhedron from the Gaussian image, which is represented by a series of vertices and facets. This convex polyhedron is finally run through the program standardtri, which converts all facets into triangular facets.

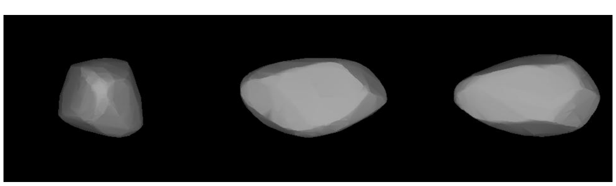

Figure 3: Shape model of 832 Karin (pole solution one) archived in DAMIT

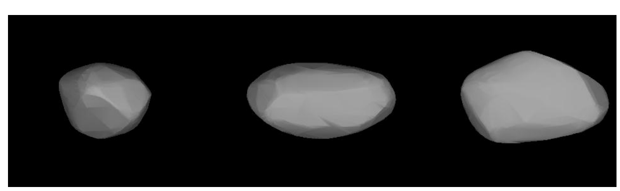

Figure 4: Shape model of 832 Karin (pole solution two) archived in DAMIT

4 Results

We were unable to resolve the ambiguity in the shape model and pole solution in 832 Karin over our three nights of observational data. Our results were consistent with the two models/solutions contained within DAMIT. For pole solution one, we obtained an ecliptic longitude for the pole of 242 degrees, with an ecliptic latitude of 46 degrees. This pole solution was generated using a best fit rotational period of 18.35123 hours. The 180 degree pole ecliptic longitude ambiguity due to limited geometry seems to be apparent in the parameters of pole solution two. For solution two, we obtained an ecliptic longitude of 59 degrees, for a 183 degree difference between solutions one and two. This gave us an ecliptic latitude of 44 degrees, and a best fit rotational period of 18.35121 hours. However, our data did assist in refining the shape models of 832 Karin (Figures 5-7 and 8-10).

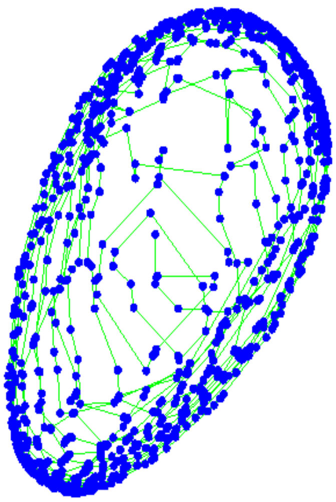

Figure 5: 832 Karin shape model using pole solution 1 (looking down z-axis)

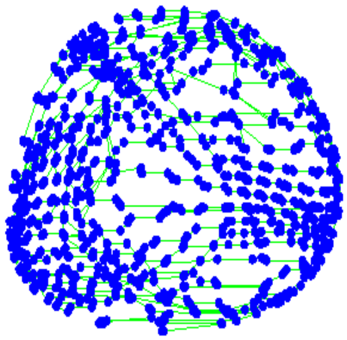

Figure 6: 832 Karin shape model using pole solution 1 (looking down y-axis)

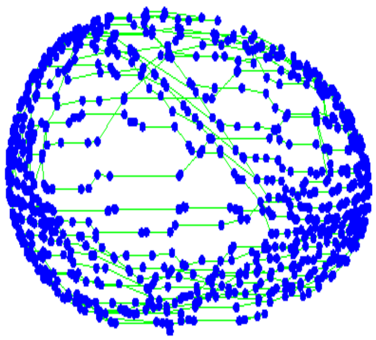

Figure 7: 832 Karin shape model using pole solution 1 (looking down x-axis)

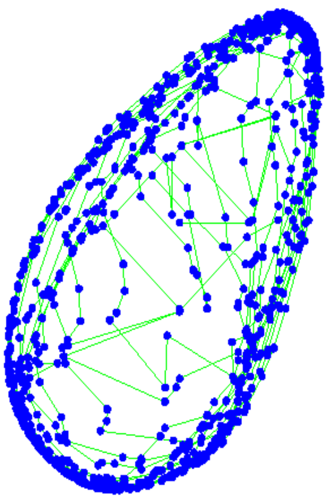

Figure 8: 832 Karin shape model using pole solution 2 (looking down z-axis)

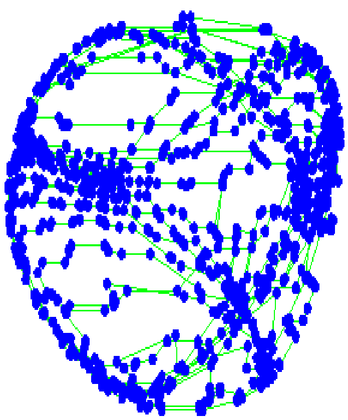

Figure 9: 832 Karin shape model using pole solution 2 (looking down y-axis)

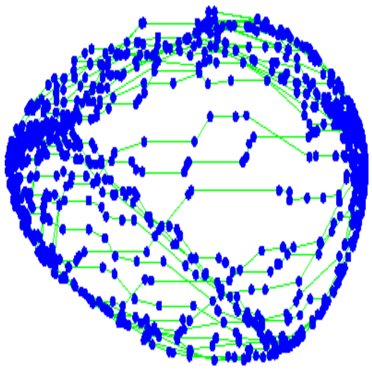

Figure 10: 832 Karin shape model using pole solution 2 (looking down x-axis)

5 Conclusions

Further ground-based observational data will be required in order to resolve the ambiguity in the shape model and pole solution for 832 Karin. At present time, the Karin family is moving out of our optimal observational range at Table Mountain Observatory. The next occasion for photometric data to be obtained at our location will occur in the summer of 2013. Because the Karin cluster is such a valuable target in collisional dynamics and post-formational process research, future lightcurve data is likely, as is resolution of the ambiguities.

6 Acknowledgments

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7 References

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