Shape Models of Minor Planets 242 Kriemhild and 287 Nephthys.

Michael Fauerbach[1], Scott A. Marks[1], Raoul Behrend[2], Laurent Bernasconi[3], Jean-Gabriel Bosch[4], Matthieu Conjat[5], Claudine Rinner[6], René Roy[7], [1]*Egan Observatory, Florida Gulf Coast University (mfauerba@fgcu.edu),* [2]*Obs. de Geneva, Switzerland,* [3]*Les Engarouines Observatory, France,*[4]*Collonges Observatory, France,* [5]*Cabris, France,* [6]*Ottmarsheim Observatory, France,* [7]*Blauvac Observatory, France*

Introduction: Asteroids are generally too small to visually distinguish the shape through Earth-bound observations. Fortunately, light curve inversion of disc-integrated photometry has been shown to be a viable source to obtain information about the shape and spin axis of asteroids [1],[2]. In early 2007 two target candidates for an initial shape modeling study at the Egan Observatory at Florida Gulf Coast University were selected. Minor Planets 242 Kriemhild and 287 Nephthys were chosen because past observations had already been obtained at the Egan Observatory to determine their rotational periods.

Observations and data reduction: Numerous photometric observations spanning several apparitions and a wide range of phase angles, particularly large angles, are essential for a precise shape model because the asteroid must be observed from different viewing geometries. As a consequence, a concerted effort between several European and American observatories was initiated to increase accuracy. In conjunction with these observatories, data was collected over three apparitions and an assortment of phase angles, with some greater than 20^o, on each of the target asteroids. Details on the equipment and experimental methods employed by the Egan Observatory can be found in [3] and a summary of the observational dates and parameters can be found in Table 3. The data were originally analyzed with MPO Canopus Version 9, which employs differential aperture photometry to determine the values used for analysis. Fig. 1 shows a typical lightcurve obtained at the Egan Observatory. Please note, that the observational range spans over three months in order to maximize the observed phase angles on both sides of opposition.

Lightcurve inversion was performed via the windows-based program MPO LCInvert [4], which utilizes the original FORTRAN and C code as developed by Kaasalainen and Durech [1]. The software calculates 30 possible shape models with varying pole orientations and statistical analysis was performed on each of the potential models to select which had the highest accuracy. The chosen solution had to meet several requirements [1]: a) the χ^2 is at least 10% smaller than the majority b) the dark area must be less than one c) the RMS should be smaller than the majority d) the model must appear physically plausible. Finally, the selected model's 'modeled' lightcurves were compared to the actual lightcurves to determine that the results are valid (see Fig. 2).

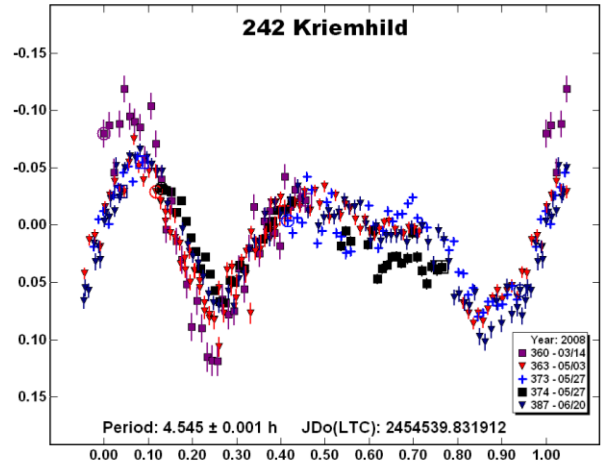

Fig. 1: Lightcurve for Minor Planet 242 Kriemhild, as obtained in 2008.

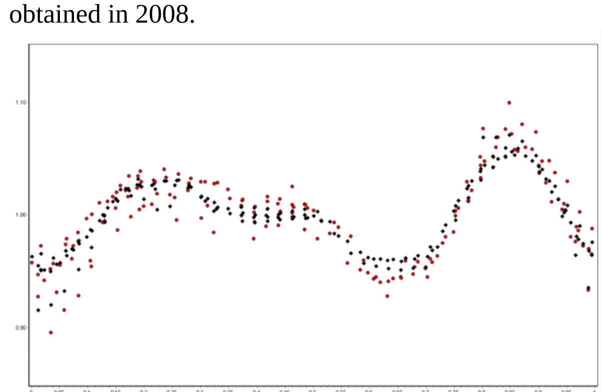

Fig. 2: Comparison between actual lightcurve for Minor Planet 242 Kriemhild (same as Fig. 1) (black dots), and 'modeled' lighcurve (red dots).

Results:

Following careful analysis, shape models and pole orientations were established for both target asteroids 242 Kriemhild and 287 Nephthys. A summary of the statistical analysis of the results can be found in Table 1 below.

Table 1: Statistical details of the chosen models for the target asteroids.

Asteroid	χ^2	***RMS***	***Dark Area (%)***
242 Kriemhild	0.050359	0.0102	0.1342038
287 Nephthys	0.160301	0.0116	0.4002733

The sidereal period, as well as the pole location for the two target asteroids can be found in Table 2. It should be pointed out that the sidereal period is accurate to the digits presented in Table 2. However, the typical error in the pole direction obtained by comparison of lightcurve inversion results with ground truths from space probes and laboratory experiments [5] is about 5^o to 10^o of arc.

Table 2: Shape Model results for target asteroids. The table lists the sideral period, and the ecliptic latitude B and longitude λ of the geographic north pole.

Asteroid	*Period* (hrs)	*B* (deg)	*λ* (deg)
242 Kriemhild	4.54529	-37	115
287 Nephthys	7.60479	34	354

Table 3: Observational data for target asteroids. Phase angle α, phase angle bisector ecliptic longitude L_{PAB}, and phase angle bisector ecliptic latitude B_{PAB}, each given at the middle of the listed observation interval.Observers are denoted as [1] Bosch, [2] Warner [6], [3] Rinner, [4] Roy, [5] Fauerbach and Marks, [6] Conjat, [7] Bernasconi

Date Range and Observers	*α (deg)*	*L_{PAB} (deg)*	*B_{PAB} (deg)*
242 Kriemhild			
7/27/2004 – 7/28/2004[1]	*5.1*	*305.6*	*13.7*
8/8/2004 – 8/16/2004[2]	*7.1*	*305.3*	*13.5*
9/1/2004 – 9/5/2004[3]	*12.5*	*305.5*	*12.9*
11/7/2005[4]	*8.9*	*22.4*	*0.1*
12/2/2005 – 12/3/2005[5]	*16.4*	*23.6*	*-1.0*
1/19/2007 – 1/20/2007[5]	*10.5*	*136.1*	*-14.1*
2/15/2007 – 2/22/2007[5]	*8.5*	*136.9*	*-13.6*
4/12/2007 – 4/13/2007[5]	*21.7*	*142.6*	*-10.5*
3/13/2008[5]	*19.2*	*238.1*	*4.5*
5/2/2008[5]	*8.4*	*241.9*	*7.1*
5/26/2008[5]	*3.5*	*241.7*	*8.2*
6/19/2008[5]	*10.5*	*241.7*	*8.8*
287 Nephthys			
4/25/2000 – 5/1/2000[6]	*11.3*	*200.3*	*12.0*
5/20/2000 – 5/30/2000[6]	*20.4*	*202.7*	*11.9*
6/13/2004 – 6/18/2004[7]	*7.5*	*258.4*	*12.3*
7/24/2004 – 7/25/2004[5]	*20.1*	*261.3*	*10.0*
8/12/2004 – 8/21/2004[5]	*24.5*	*265.5*	*8.3*
2/9/2007 – 2/22/2007[5]	*11.8*	*168.9*	*4.7*
4/7/2007 – 4/12/2007[5]	*14.8*	*170.1*	*7.5*

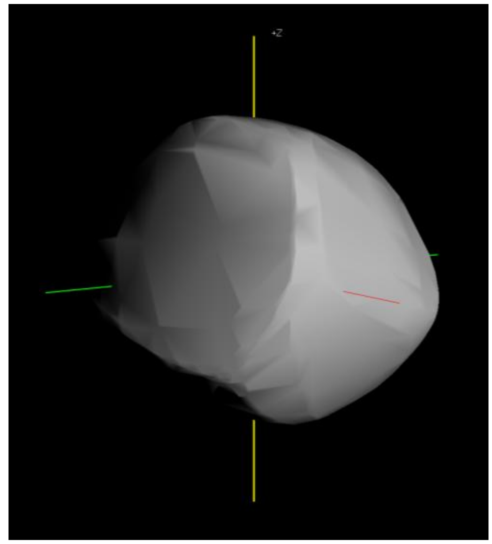

Fig. 3: Shape model of 242 Kriemhild. This equatorial perspective represents the asteroid at an arbitrary point along its equator. The top of the image is geographic north.

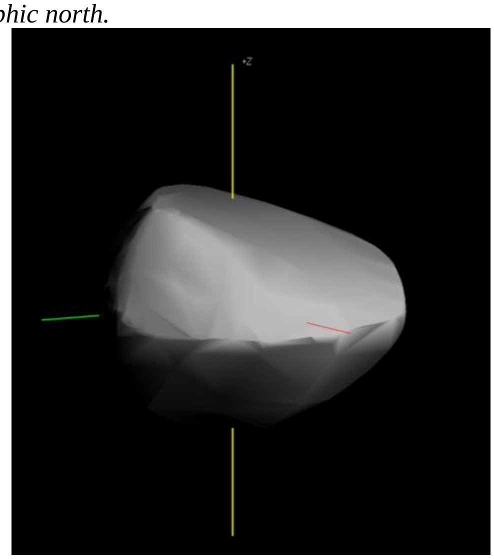

Fig. 4: Shape model of 287 Nephthys. This equatorial perspective represents the asteroid at an arbitrary point along its equator. The top of the image is geographic north.

References:

[1] Kaasalainen, M., & Torppa, J. 2001, Icarus, 153, 24. [2] Marchis, F., et al. 2006, Icarus, 185, 39. [3] Fauerbach, M. and Bennett, T. (2005), *The Minor Planet Bulletin* **32-2**, 34-35. [4] B.D. Warner, http://www.minorplanetobserver.com/MPOSoftware/MPOLCInvert.htm [5] Kaasalainen, et al., 2005, A&A, 440, 1177, [6] Warner, (2004) Minor Planet Bulletin 32-1

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