Spin axis and shape model for 1117 Reginita

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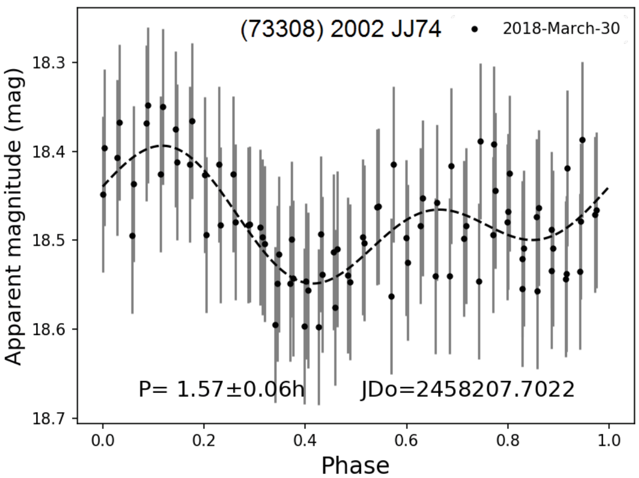

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SPIN AXIS ANDSHAPE MODEL FOR 1117 REGINITA

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We present shape and spin axis model for main-belt asteroid 1117 Reginita. The model was achieved with the lightcurve inversion process using combined dense photometric data acquired from nine apparitions between 2003-2018 and sparse data from USNO Flagstaff. Analysis of the resulting data found a sidereal period P = 2.946472 ± 0.000002 hours and two mirrored pole solutions at (λ = 0°, β = 43°) and (λ = 174°, β = 47°) with an uncertainty of ± 5 degrees.

The spin-axis determination of an asteroid is an important source of statistical data for physical studies of asteroids (e.g. collisional families evolution). The lightcurve inversion method is one of the main sources of the spin-axis measurement (Durech et al. 2010). We aimed to contribute to this goal.

The minor planet 1117 Reginita was observed in the past by the authors in order to acquire data for lightcurve inversion work (Franco et al., 2018; Galdies et al., 2019). A search in the asteroid lightcurve database (LCDB; Warner et al., 2009) shows many entries covering a wide range of phase angle bisectors. This presented an ideal starting point for lightcurve inversion. Dense photometric data were downloaded from ALCDEF (ALCDEF, 2019) and from CDS service (CDS, 2018). Sparse data were taken from the Asteroids Dynamic Site (AstDyS-2, 2018).

The observational details of the dense data used are reported in Table I with the mid date of the observing campaign, longitude and latitude of phase angle bisector (L_{PAB}, B_{PAB}).

Lightcurve inversion was performed using *MPO LCInvert* v.11.7.5.1 (BDW Publishing, 2016). For a description of the modeling process see the *LCInvert Operating Instructions Manual* and Warner et al. (2017). Our data set of observations had sparse data from (689) USNO Flagstaff station in addition to the dense data. Figure 1 shows the wide PAB longitude/latitude distribution for dense/sparse data used in the lightcurve inversion process. Figure 2 (top panel) shows the sparse photometric data distribution (intensities vs JD) and (bottom panel) the corresponding phase curve (reduced magnitudes vs phase angle).

Reference	Mid date	PABL°	PABB°
Kryszczynska et al.(2012)	2003-03-26	82	-3
Kryszczynska et al.(2012)	2004-03-09	163	2
Kryszczynska et al.(2012)	2005-09-15	11	-4
Kryszczynska et al.(2012)	2007-01-22	127	-2
Kryszczynska et al.(2012)	2008-06-28	274	6
Kryszczynska et al.(2012)	2010-01-16	93	-4
Kryszczynska et al.(2012)	2011-04-07	196	5
Waszczak et al. (2015)	2014-02-21	152	0
Franco et al. (2018); Galdies et al.(2019)	2018-05-26	244	7

Table I. Observational details for the data used in the lightcurve inversion process for 1117 Reginita.

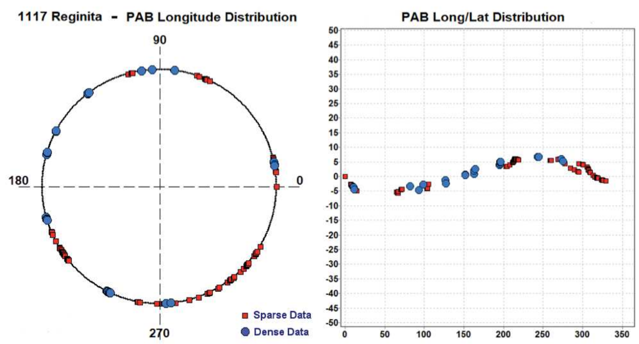

Figure 1. PAB longitude and latitude distribution of the data used for the lightcurve inversion model.

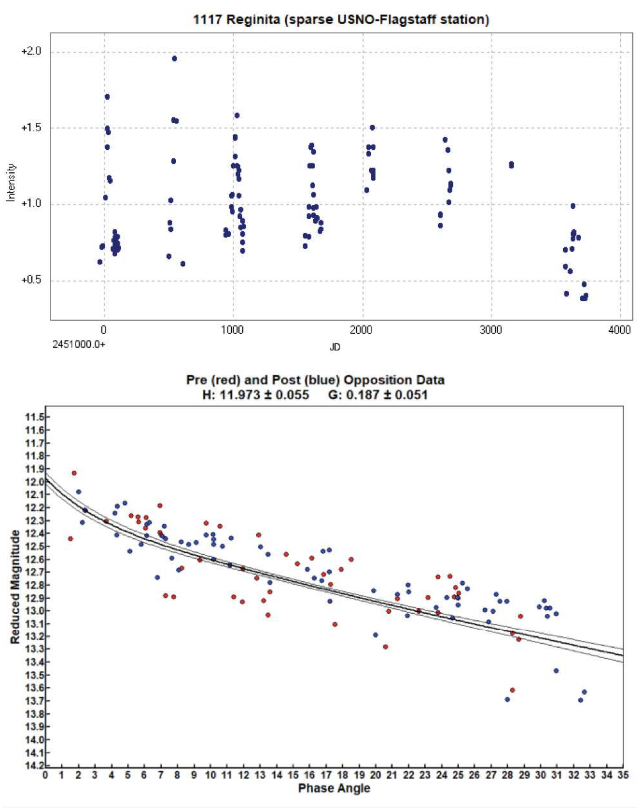

Figure. 2. Top: sparse photometric data point distribution from USNO Flagstaff station. Bottom: phase curve obtained from the sparse data.

The sidereal period search was started around the average of the synodic periods found in the asteroid lightcurve database (LCDB; Warner et al., 2009). We found no other sidereal periods with a Chi-Sq within 10% of the lowest Chi-Sq (Figure 3), thus giving good confidence in the period solution.

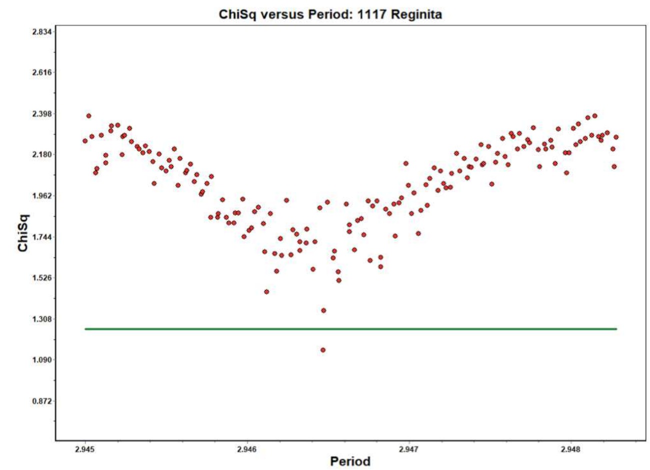

Figure 3. The period search for 1117 Reginita shows no other Chi-Sq values within 10% of the lowest value.

The pole search was started using the "medium" option with the previously found sidereal period set to "float". The "dark facet" weighting factor was set to 0.5 and the number of iterations was set to 50. From this step we found two roughly mirrored lower Chi-Sq solutions (Figure 4) separated by 180° in ecliptic longitude, (0°, 45°) and (180°, 45°).

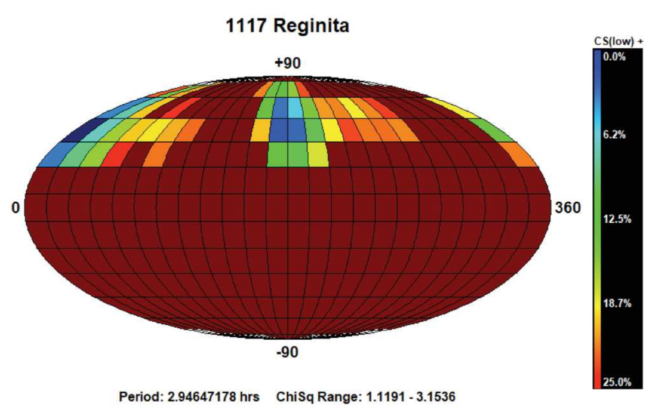

Figure 4. Pole search distribution. The dark blue indicates the better solutions (lower Chi-Sq), while maroon the worst ones.

The subsequent "fine" search that was centered on these rough positions allowed us to refine the position of the pole (Figure 5). The analysis shows two clustered solutions of ecliptic longitude-latitude pairs within 5° that had Chi-Sq values within 5% of the lowest value.

The two best solutions (lower two Chi-Sq) are reported in Table II. The sidereal period was obtained by averaging the two solutions found in the pole search process. Typical errors in the pole solution are ± 5° and the uncertainty in sidereal period has been evaluated as a rotational error of 10° over the total time span of the dense data set. Figure 6 shows the shape model (first solution) while Figure 7 shows the fit between the model (black line) and some observed lightcurves (red points).

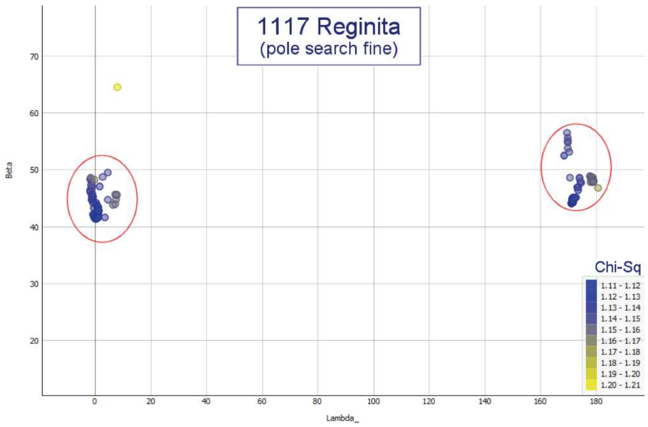

Figure 5. The "fine" pole search shows two clustered solutions centered at the ecliptic longitude/latitude (1°, 44°) and (173°, 47°) with radius approximately of 5 degrees and Chi-Sq values within 5% of the lowest value.

λ °	β °	Sidereal Period (hours)	RMS
0	43	2.946472 ± 0.000002	0.0331
174	47		0.0334

Table II. The two spin axis solutions for 1117 Reginita (ecliptic coordinates). The sidereal period was the average of the two solutions found in the pole search process.

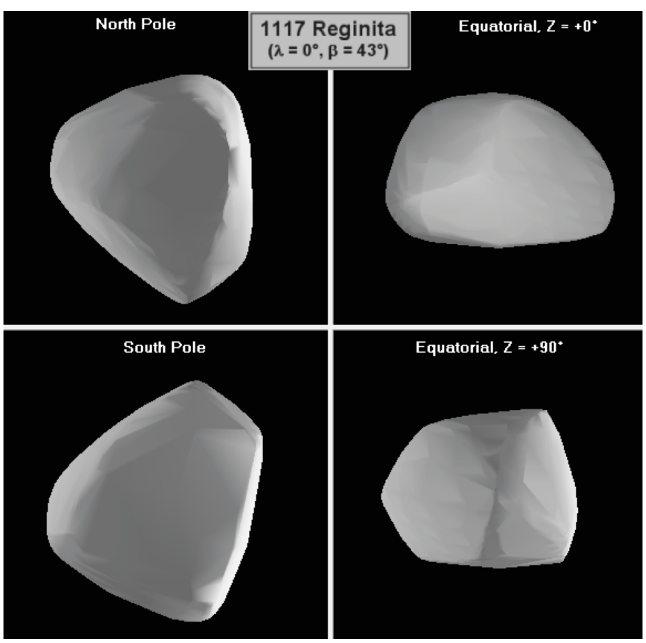

Figure 6. The shape model for 1117 Reginita (λ = 0°, β = 43°).

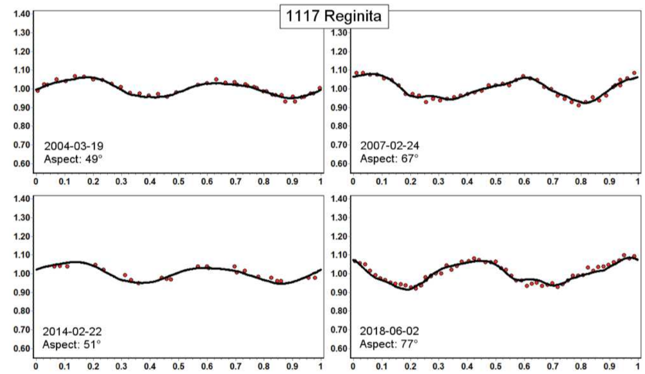

Figure 7. Model fit (black line) versus observed lightcurves (red points) for (λ = 0°, β = 43°) solution.

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