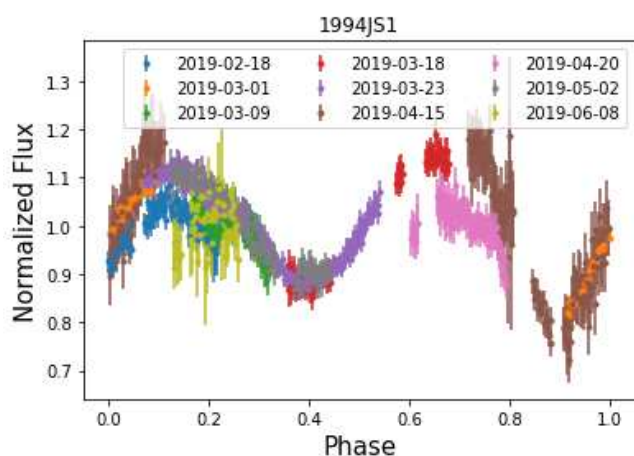




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SPIN-SHAPE MODEL FOR 118 PEITHO

Lorenzo Franco
Balzaretto Observatory (A81), Rome, ITALY
lor_franco@libero.it

Frederick Pilcher
4438 Organ Mesa Loop
Organ Mesa Observatory (G50)
Las Cruces, NM 88011 USA

Brian D. Warner
Center for Solar System Studies (CS3) / MoreData!
Eaton, CO 80615 USA

Alessandro Marchini, Leonella-Filippa Saya
Astronomical Observatory, DSFTA - University of Siena (K54)
Siena, ITALY

Audejean Maurice
Observatoire de Chinon (B92)
Mairie de Chinon, Chinon, FRANCE

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We present a shape and spin axis model for main-belt asteroid 118 Peitho. The model was achieved with the lightcurve inversion process, using combined dense photometric data acquired from five apparitions between 1977-2020 and sparse data from USNO Flagstaff. Analysis of the resulting data found a sidereal period $P = 7.806397 \pm 0.000009$ hours and two mirrored pole solutions at $(\lambda = 179^\circ, \beta = 60^\circ)$ and $(\lambda = 345^\circ, \beta = 39^\circ)$ with an uncertainty of ± 10 degrees.

The minor planet 118 Peitho has been observed at past oppositions and most recently (2020 opposition) by Pilcher at Organ Mesa Observatory (Pilcher, 2020) and by Marchini and Saya at Astronomical Observatory of the University of Siena. Dense photometric data were downloaded from Asteroid Photometric Catalogue (APC, 1993) and from ALCDEF (ALCDEF, 2019). Moreover, in order to improve the coverage at various aspect angles, we also used sparse data from USNO Flagstaff Station (MPC Code 689), taken from the Asteroids Dynamic Site (AstDyS-2, 2020).

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

Reference	Mid date	# LC	L_{PAB}°	B_{PAB}°
Stanzel, Schober (1980)	1977-12-05	1	76	5
Warner (2009)	2009-05-13	3	177	6
Audejean (2013) Web	2013-04-16	2	196	5
Pilcher (2017)	2017-05-18	3	216	1
Pilcher (2020)	2020-01-11	2	103	9
Franco et al. (2020)	2020-01-22	1	104	10

Table I. Observational details for the data used in the lightcurve inversion process for 118 Peitho.

Lightcurve inversion was performed using *MPO LCInvert* v.11.8.2.0 (BDW Publishing, 2016). For a description of the modeling process see *LCInvert Operating Instructions Manual* (Durech et al., 2010; and references therein).

Figure 1 shows the 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).

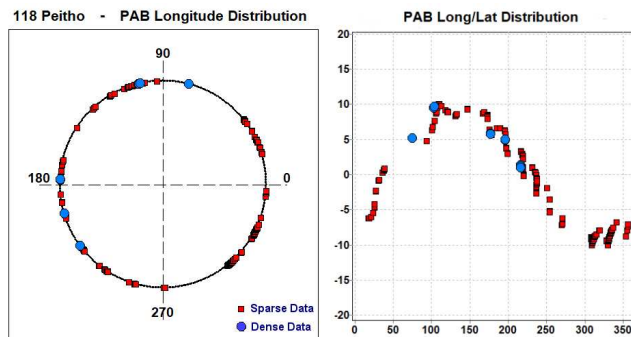


Figure 1. PAB longitude and latitude distribution of the data used for the lightcurve inversion model.

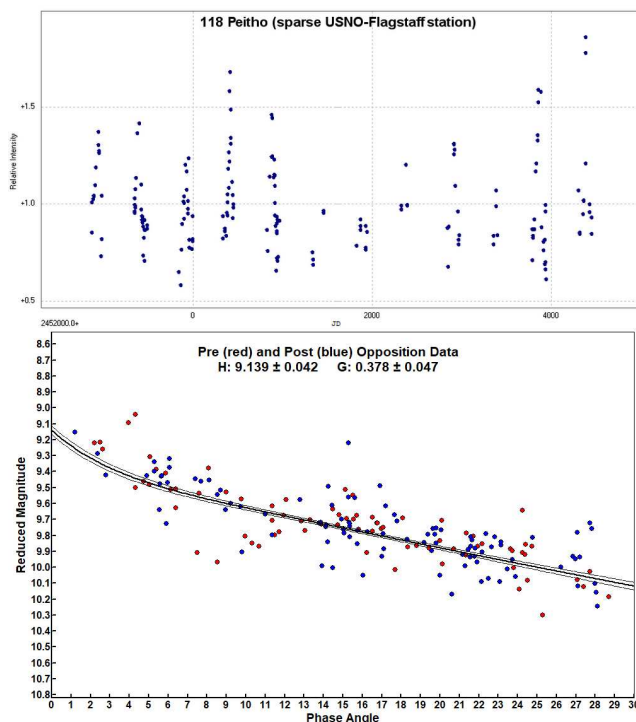


Figure 2. Top: sparse photometric data point distribution from (689) USNO Flagstaff station (relative intensity of the asteroid's brightness vs Julian Day). Bottom: phase curve obtained from sparse data (reduced magnitude vs phase angle).

In the analysis the processing weighting factor was set to 1.0 for dense data and to 0.3 for sparse data. The “dark facet” weighting factor was set to 0.5 to keep the dark facet area below 1% of total area and the number of iterations was set to 50.

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 one isolated sidereal period with a Chi-Sq value within 10% of the lowest Chi-Sq (Figure 3).

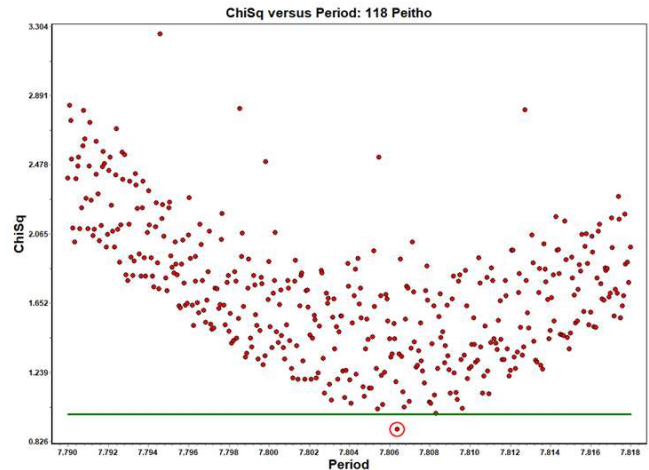


Figure 3. The period search for 118 Peitho shows one isolated sidereal period with Chi-Sq values within 10% of the lowest value.

The pole search consisted of looking at 312 discrete, fixed pole positions while allowing the previously found sidereal period to “float.” From this step we found two roughly mirrored lower Chi-Sq solutions (Figure 4) separated by about 180° in longitude at ecliptic longitude-latitude pairs (180°, 60°) and (345°, 45°).

The subsequent “fine” search, centered on these rough positions, allowed us to refine the position of the pole (Figure 5). The analysis shows two set of clustered solutions within 10° of radius that had Chi-Sq values within 10% of the lowest value, centered at ecliptic longitude-latitude (179°, 59°) and (345°, 40°).

The two best solutions (lower 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 $\pm 10^\circ$ and the uncertainty in sidereal period has been evaluated as a rotational error of 20° 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).

λ°	β°	Sidereal Period (hours)	RMS
179	60	7.806397 ± 0.000009	0.0172
345	39		0.0174

Table II. The two spin axis solutions for 118 Peitho (ecliptic coordinates) with an uncertainty of ± 10 degrees. The sidereal period was the average of the two solutions found in the pole search process.

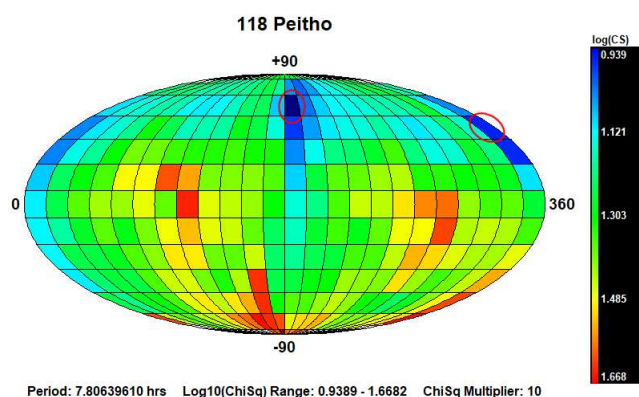


Figure 4. Pole search distribution. The dark blue region indicates the smallest Chi-Sq value while the dark red region indicates the largest.

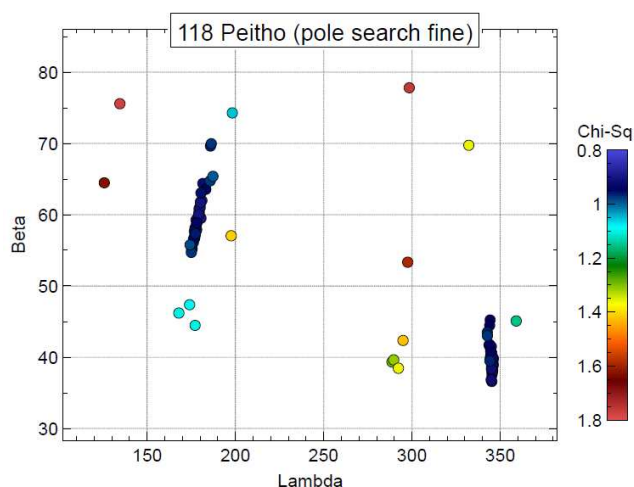


Figure 5. The "fine" pole search shows two clustered solutions centered at the ecliptic longitude/latitude (179°, 59°) and (345°, 40°) with radius approximately of 10° and Chi-Sq values within 10% of the lowest value.

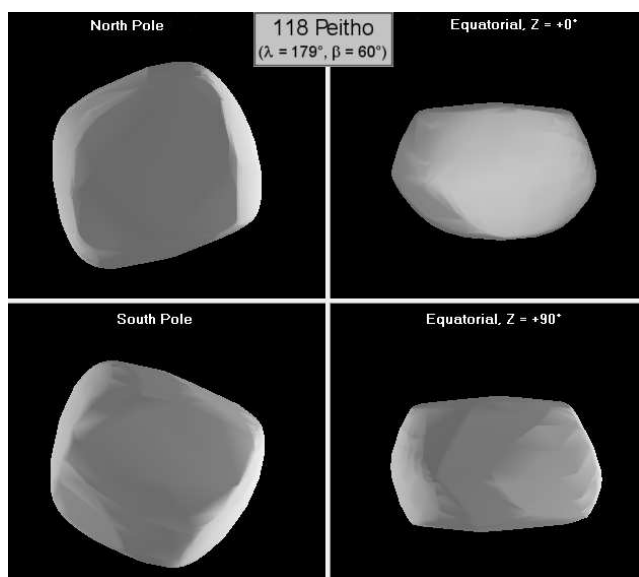


Figure 6: The shape model for 118 Peitho ($\lambda = 179^\circ$, $\beta = 60^\circ$).

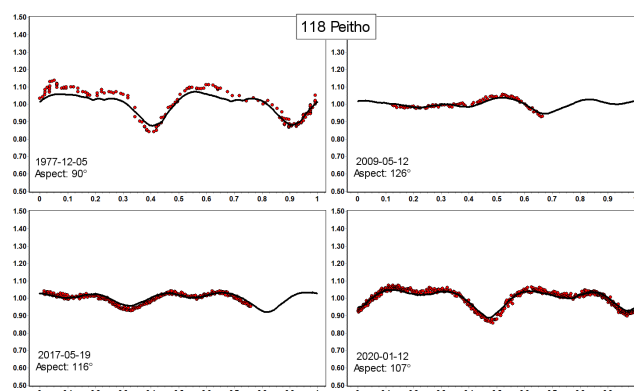


Figure 7: Model fit (black line) versus observed lightcurves (red points) for ($\lambda = 179^\circ$, $\beta = 60^\circ$) solution.

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