

PERIOD DETERMINATION FOR 182 ELSA: A COLLABORATION TRIUMPH

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The synodic rotation period and amplitude of 182 Elsa are found to be 80.088 ± 0.002 h and 0.72 ± 0.03 mag.

Prior to this investigation only two lightcurve papers about 182 Elsa appear to have been published. Harris et al. (1980) observed on five nights, 1979 Dec. 3-7, and found a period of $P \sim 80$ h and amplitude $A \sim 0.7$ mag. A second set of observations published by Harris et al. (1992) were made on 1981 July 25–Aug. 9 and show only the rising and falling parts of the lightcurve. The amplitude was at least 0.6 mag, but no period could be found.

The three authors agreed to undertake a collaborative investigation of 182 Elsa from their widely separated longitudes. The western observers (Krajewski or Pilcher) could start a photometric run shortly after, or near opposition before the eastern observer (Benishek) ended his and thereby get precise instrumental magnitude adjustments to obtain a de facto lightcurve of up to sixteen hours duration. Benishek at Belgrade Observatory used a Meade 0.4-m LX200 GPS f/10 Schmidt-Cassegrain. An Apogee AP47p CCD was used for the October and November sessions, and a SBIG ST8 for the December session. Krajewski at Dark Rosanne Observatory used a 0.20-m Schmidt-Newtonian reflector operating at f/4 with a SBIG ST-402 CCD. Pilcher at Organ Mesa Observatory employed a Meade 0.35-m LX200 GPS f/11 Schmidt-Cassegrain and SBIG STL-1001E CCD. Differential photometry and lightcurve construction were made by all observers with *MPO Canopus*. This software made sharing and linking of the data much easier.

A well-defined minimum was recorded on 2008 Oct. 13, the first night of observation, near 9h UT. From the expected 80-hour period, another minimum was predicted for 9h UT Oct. 23. This was observed as predicted. By this date nearly 70% phase coverage had been obtained, indicating a period slightly greater than 80 hours with the amplitude about 0.75 magnitudes. In the next ten days, through November 2, additional observations completed full phase coverage except for some very small gaps, and the period spectrum graph showed no other minima between 40-120 hours. Most of the observations included in this report had already been obtained at larger phase angles: 22.8° on Oct. 13 down to 14.4° on Nov. 2. These defined the amplitude $A = 0.72 \pm 0.03$ mag that is plotted in the accompanying lightcurve. A small number of additional lightcurves were obtained, in some cases covering extrema, to further refine the period and provide data useful for future spin/shape modeling. Based on lightcurves obtained from 2008 Oct. 13-2009 Jan. 3, a period of $P = 80.088$

± 0.002 h provides a best fit to all data. Observations were binned in sets of 5 separated by no more than 10 minutes to reduce the number of points in the lightcurve and make it more readable.

Lightcurve amplitudes nearly always increase at larger phase angles due to shadowing effects. Lightcurves were obtained at nearly the same lightcurve phase on a linear descending branch and show the following slopes: Oct. 13, $\alpha = 22.8^\circ$, and Oct. 23, $\alpha = 19.0^\circ$, both with slope 0.072 mag/h; and Dec. 2, $\alpha = 3.8^\circ$, slope 0.052 mag/h. While these measurements do not have a high numerical accuracy, they do suggest $A(0^\circ) \sim 0.55$ -0.60 mag. The ratio of maximum to minimum equatorial radii (a/b) is found from

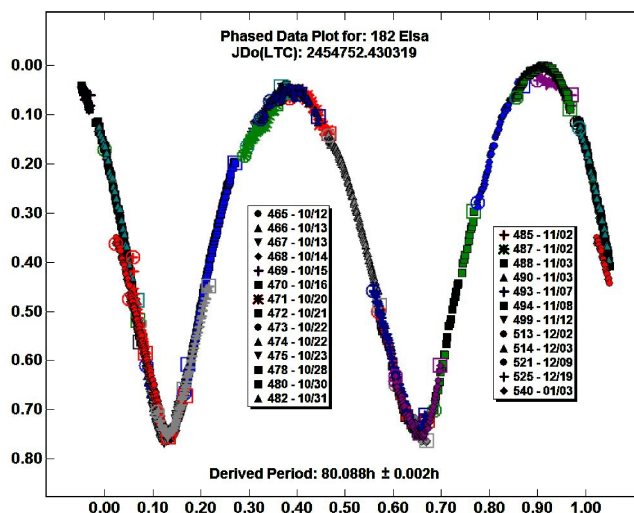
$$a/b \geq 10^{(0.4 \Delta M)}$$

Assuming $\Delta M = 0.6$ for $\alpha(0^\circ)$, this implies $a/b \sim 1.7$ for the asteroid. The ratio of minimum equatorial to polar radii (b/c) cannot be found from data obtained to date.

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CALL FOR OBSERVATIONS

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Observers who have made visual, photographic, or CCD measurements of positions of minor planets in calendar year 2008 are encouraged to report them to the author on or before 2009 April 1. This will be the deadline for receipt of reports that can be included in the "General Report of Position Observations for 2008," expected to be published in *MPB* Vol. 36, No. 3.

MULTI-COLOR PHOTOMETRY OF 1998 BE7

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Multi-color photometry of the high orbital eccentricity asteroid, 1998 BE7, was conducted in the course of Lulin Sky Survey (LUSS) from 2008 October 1 to November 5. These data allowed determination of the rotation period to be 6.6768 ± 0.0001 h, as well as color indices of $B-V = 0.727 \pm 0.063$, $V-R = 0.405 \pm 0.008$, and $V-I = 0.897 \pm 0.009$. These indices suggest that 1998 BE7 could be a D-type asteroid. Assuming a slope parameter $G = 0.086$ and albedo (p_V) 0.058 ± 0.004 , the absolute magnitude H is estimated to be 14.773 ± 0.323 , with a corresponding diameter of 5.0-7.0 km.

Asteroid 1998 BE7 was discovered by the NEAT program on 1998 January 24 (Williams, 1998) with orbital elements of $a = 3.08$, $e = 0.51$. It made close approaches to Earth in 1998 and 2003 but no photometric observations were made due to unfavorable positions. The asteroid made another close approach to the Earth in 2008 November, reaching $V = 15.3$ mag – the brightest over the decade. Hence, it was chosen for photometric purpose in the course of Lulin Sky Survey (LUSS). From 2008 October 1 to November 5, 10 nights of data were obtained using our 0.41-m Ritchey-Chretien telescope equipped with a 4-mega pixel back-illuminated CCD. Data from two nights were calibrated with standard fields. The data were reduced with Raab's *Astrometrica* and Warner's *MPO Canopus*. The observations clearly yielded a period of 6.6768 ± 0.0001 h (Figure 1). Considering the relatively large magnitude amplitude (about 0.97 mag) and phase angle of the target at the time ($\sim 25^\circ$), it can be suggested that 1998 BE7 has an elongated shape.

BVRI-filter observations of 1998 BE7 and Landolt fields were made on 2008 November 5. This enabled us to measure the asteroid's color indices. The results are $B-V = 0.727 \pm 0.063$, $V-R = 0.405 \pm 0.008$, and $V-I = 0.897 \pm 0.009$. From the asteroid taxonomic method describe by Bus and Binzel (2002), it can be inferred that the color indices of BE7 are consistent with a D-type asteroid. Since VR-filter observations of BE7 and Landolt fields were obtained on both 2008 October 27 and November 5, it was possible to compute the absolute magnitude based on a given slope parameter G . Assuming $G = 0.086$ (Harris, 1989), the absolute magnitude (H) is estimated to be 14.773 ± 0.323 (Figure 2). We should point out that there is a systematic error among the

data due to unsatisfactory quality of the standard field observations, which might be as large as 0.15 mag.

The approximate size of an asteroid can be determined by (Warner 2007):

$$\log D = 3.1235 - 0.2H - 0.5 \log(p_V)$$

Where D is diameter of the asteroid in km, H is absolute magnitude, and p_V is albedo of the asteroid. Assuming the asteroid's albedo is 0.058 ± 0.004 , which is based on the assumed type, the diameter is estimated to be 5.0-7.0 km.

The lack of calibrated observations caused some difficulties when doing our lightcurve analysis, specifically because different solutions were possible by simply adjusting nightly zero points. This becomes a significant issue for targets without a prominent feature in their lightcurve. We recommend that lightcurve data should always be calibrated, at least on an internal system, in order to rule out false solutions.

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