

PERIOD DETERMINATION FOR 35 LEUKOTHEA

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At longitude 357 to 347 degrees 35 Leukothea is found to have a 31.893 ± 0.004 hour period, monomodal lightcurve, and 0.07 ± 0.02 magnitude amplitude. Approximate pole positions and ratio a/b of maximum to minimum equatorial radii are also found.

Lightcurves of 35 Leukothea were obtained at the Organ Mesa Observatory on 18 nights 2007 Aug. 5-Oct. 8. Equipment consists of a 35.4 cm Meade LX 200 GPS S-C and SBIG STL 1001-E CCD, with 60 second unguided exposures through a clear filter, differential photometry only. Because of the large number of data points, 3103 for the 18 nights, they have been binned in sets of 5 with time interval not exceeding 10 minutes for the lightcurve, reducing the number to 633. Despite the long interval of observation, including 9 consecutive nights August 12-20, both a 27.355 hour 0.04 magnitude amplitude bimodal lightcurve and a 31.893 hour 0.07 magnitude amplitude monomodal lightcurve are allowed by this study. The lightcurve phased to 31.893 hours is included here.

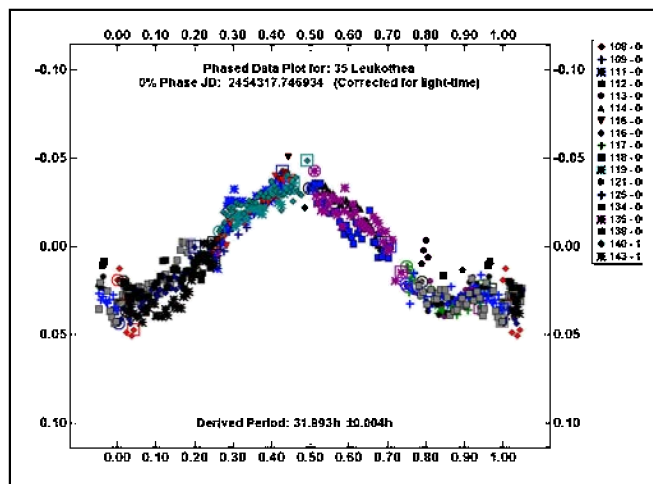
It should be noted that 31.893 hours is almost exactly a 4:3 commensurability with the Earth's rotation period from the observational viewpoint. The Earth's sidereal rotation period is 23.934 hours, but asteroids near opposition when most lightcurves are obtained retrograde at about 1 minute of right ascension daily. Hence a period of 23.92 hours is synchronous with Earth's in the sense that this is the interval between successive transits of an asteroid. A 31.893 hour period for Leukothea is to 3 decimal places a perfect 4:3 commensurability. This shows clearly on the lightcurve, where 7 to 8 hour photometry sessions possible in this season appear in 4 segments barely or not quite overlapping. The lack of significant overlap between sessions makes more difficult the adjustment of instrumental magnitudes to best fit, and increases the error in the amplitude. It should be noted that the segments centered near phases 0.35 and 0.60 must be lowered about 0.035 magnitudes for the best fitting 27.355 hour lightcurve.

Prior to this study only two photometric investigations of 35 Leukothea appear to have been published. The first, only 50 minutes in duration by Lagerkvist et al. (1987), shows no variation beyond 0.02 magnitude scatter from 8:55-9:45 UT 1985 Mar. 20. The second, by Weidenschilling et al. (1990) from 1988 Dec. 21 and 22, is sufficient to resolve the period ambiguity. Dec. 21 the brightness first slowly, then rapidly decreased by about 0.38 magnitudes from about 4h30m to 11h30m UT. Dec.22 the brightness decreased about 0.05mag from about 2h to 4h UT, then increased by about 0.25mag to 10h30m UT. There is a clearly defined minimum Dec. 22 near 4h and a maximum Dec. 21 indicated near 3h to 4h. This led Weidenschilling et al. to deduce an approximate period of 32 hours, consistent with the current study. A 27.355 hour period applied to Weidenschilling's lightcurve superposes a rising segment with a falling segment, and is also inconsistent with maximum and minimum observed about 24 hours apart. This rules out a 27.355 hour period. The small 0.07m amplitude in 2007 at longitudes 357 to 347 degrees indicates a near polar aspect for 2007, which in turn implies that

the 1988 lightcurves at longitude 87 degrees are at near equatorial aspect. The 31.893 hour period with a monomodal lightcurve near polar aspect and bimodal lightcurve near equatorial aspect fully explain both the respective 2007 and 1988 observations. Monomodal lightcurves near polar aspect and bimodal ones near equatorial aspect have been established for other asteroids. Read for example Warner et al. (2006). The 2007 observations by themselves are also explained by a bimodal, symmetric lightcurve of period 63.79 hours. But no reasonable shape model other than the bimodal one can produce 0.38m amplitude as observed in 1988. An approximate 32 hour period produces maximum and minimum 3/4 cycle apart separated by about 24 hours, observed in 1988. An approximate 64 hour period produces adjacent maximum and minimum about 16 hours apart, which conflicts with the 1988 observations and rules out a 64 hour period. Therefore I claim that 31.893 hours is the correct period. The actual error may be considerably greater than the formal error of ± 0.004 hours, particularly because of inaccuracies linking separate nights when there is a high degree of commensurability

This study also provides for 35 Leukothea approximate positions of the rotational pole, and of the ratio a/b of maximum to minimum equatorial radii. It should be remembered that except in unusual circumstances whole disk photometry cannot distinguish between two pole positions at the same angle north or south from the asteroid's orbit and 180 degrees apart in longitude. This ambiguity cannot be resolved here. The two possible pole positions are within 15 degrees of latitude 0 degrees and either longitude 352 degrees (mean longitude of the 2007 observations) or 172 degrees. In either case the 1988 observations were at near equatorial aspect, where the amplitude is a maximum possible. The ratio a/b of maximum to minimum equatorial radii is found from $a/b \geq 10^{0.4 \Delta M}$. For $\Delta M = 0.38$ in the 1988 near equatorial aspect, a/b for 35 Leukothea is approximately 1.42. The ratio of minimum equatorial to polar radii b/c cannot be found from data obtained in 1988 and 2007.

The next opposition of 35 Leukothea is November, 2008. At this time Leukothea will be in near equatorial aspect. An amplitude exceeding 0.3 magnitudes is predicted for this event. From mid-northern latitudes 10 hour photometry sessions will be possible. Lightcurves on 4 successive nights are expected to verify a 31.9 hour period with full phase coverage and a 2 hour overlap. Additional lightcurves will be useful to decrease the $\pm$ error in the derived period and enable robust modeling of this asteroid. The author requests any northern hemisphere observers with suitable resources to make these observations.



Following completion of all the above analysis the author sent a machine readable version of all the 2007 photometry observations to shape/spin modeler Josef Durech. He replied (Durech, 2007) that although two oppositions are not sufficient to establish a robust model, “the rotation period of (35) Leukothea is close to 31.9 hours.”

Readers please take note that even fragmentary lightcurves, such as those of Leukothea in 1988 by Weidenschilling et al., can be very useful for subsequent studies. Without them the 2007 data alone are compatible with 3 ambiguous rotation periods.

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LIGHTCURVE ANALYSIS OF 1565 LEMAITRE

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The authors observed 1565 Lemaître independently in August and September 2007. The combined data set was used to determine the synodic period. This proved difficult due to the small amplitude of the lightcurve. We propose a synodic period of either 11.403 ± 0.003 hr (monomodal) with the possibility of 22.805 ± 0.007 hr (bimodal) with an amplitude of 0.04 ± 0.01 mag for either. Given the low amplitude, curves with three or more maxima and minima could not be rejected automatically, however period searches for such possibilities were not convincing.

The authors started observing 1565 Lemaître independently with Warner posting some initial results on the CALL site. After seeing this posting, Vander Haagen contacted Warner and a combined data set was created since neither set alone was producing a confident solution due to the low amplitude of the lightcurve (~ 0.04 mag) and minor variations in the curve that, at times, rivaled the total amplitude.

Period analysis was done within Canopus using the algorithm based on the FALC program by Harris (1989). Period searches were made from 1 to 50 hours, the shorter period to see if the high frequency variations in some data were significant and the longer since the general trend of the data on some nights was a steady increase or decrease with no obvious extreme point reached. The solutions suggest a synodic period of either 11.403 ± 0.003 hr (monomodal) or 22.805 ± 0.007 hr (bimodal)

Behrend et al. (2007) worked the asteroid in July and August 2007 and had similar difficulties, reporting a period of 2.4 hr. but with low confidence. Given the low amplitude in 2007, it may be safe

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to presume that the viewing aspect was pole-on and, therefore, the period of 11.403 hr is to be preferred when considering only the Warner/Vander Haagen data set.

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