The period analysis found a synodic period for 8882 Sakaetamura of 4.874 ± 0.002 h. This is different from the period reported by Hamanowa and Hamanowa (2005), who found 2.838 h with an amplitude of 0.66 mag. Their solution was a monomodal lightcurve which, given the amplitude, is not likely and so a period approximately double what they found would be more probable. On the other hand, the solution is almost identical to the one of 4.8742 ± 0.002 h found by Hills (2012).

Acknowledgements

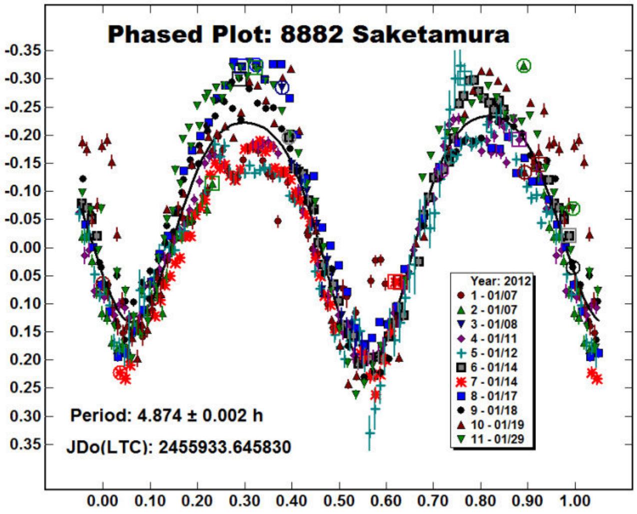
Special thanks go to Dr. Daniel A. Klinglesmith III for his guidance and help in processing and collecting the data. The author would also like to thank Dr. David J. Westpfahl of the New Mexico Institute of Mining and Technology, Department of Physics, for his encouragement and support on pursuing this research. Special thanks go to Dr. Frank T. Etscorn for providing the funding for the Observatory facilities. The author acknowledges the Title IV of the higher education act from the Department of Education.

References

Hamanowa, H., Hamanowa, H. (2005). *http://www2.ocn.ne.jp/~hamaten/astlcdata.htm*

Hills, K. (2012). "Asteroid Lightcurve Analysis at Riverland Dingo Observatory: 1394 Algoa, 1660 Wood, 8882 Sakaetamura, and (15269) 1990 XF." *Minor Planet Bul.* **39**, 239-240.

JPL Small Bodies Node (2012). *http://ssd.jpl.nasa.gov/*



LIGHT CURVE FOR 8345 ULMERSPATZ

Daniel A. Klinglesmith III
Etscorn Campus Observatory, New Mexico Tech
101 East Road
Socorro, NM 87801
dklinglesmith@mro.nmt.edu

Andrea Ferrero
Bigmuskie Observatory
Mombercelli, Asti, ITALY

Caroline Odden
Phillips Academy Observatory
Andover MA, USA

Luca Strabla, Ulisse Quadri, Roberto Girelli
Observatory of Bassano Bresciano
Brescia, ITALY

(Received: 8 May)

The main-belt asteroid 8345 Ulmerspatz was observed by a collaboration of four observatories on 24 nights between 2011 Nov 24 and 2012 Jan 12, covering solar phase angles between –22.58° and +10.48°. The average synodic period for the entire observing period is estimated to be 17.1192 ± 0.0008 h with an amplitude of 0.70 ± 0.10 mag.

The main-belt asteroid 8345 Ulmerspatz was discovered on 1987 January 22 by E. W. Elst at the European Southern Observatory. The orbital period is 3.575 years and inclination 23.4º. Over the years, it has carried designations 1987 BO1, 1968 YB, and 1994 AU2 (JPL, 2012). It is named for the Ulmerspatz (sparrow) copper statuette originally on top of the roof of the cathedral of Ulm. The legend goes that a sparrow, building its nest, showed the builders of Ulm how to move a large beam through a small entrance door.

CCD observations of 8435 Ulmerspatz were obtained by a collaboration of four observatories from late 2011 to early 2012. The Etscorn Campus Observatory used a 35.6-cm *f*/11 Schmidt-Cassegrain telescope and SBIG STL-1001E CCD with 1024x1024 24-micron pixels, which gave a plate scale of 1.25 arcseconds/pixel. The exposure time for all images was 180 seconds through a clear filter. The CCD was cooled to –30ºC or –35ºC, depending on the night-time temperature. The images processed with dark frames and flat fields and then aligned using IDL routines developed by Klinglesmith (Visual Information Solutions, 2012). The processed images were measured with *MPO Canopus* (Warner, 2011). The Bigmuskie Observatory used a 30-cm *f*/8 Ritchey-Chretien and SBIG ST-9 with 512x512 20-micron pixels resulting in a plate scale of 1.72 arcseconds/pixel. The exposure time for all images was 240 seconds through an R

Start	Stop	Phase	Period (h)	Perr	Amp	Aerr
2011-11-24	2011-12-02	-22.6	17.1128	0.0150	0.60	0.05
2011-12-03	2011-12-08	-17.9	17.1724	0.0072	0.60	0.05
2011-12-16	2011-12-24	-9.4	17.0840	0.0060	0.65	0.05
2011-12-26	2011-12-29	-2.4	17.1508	0.0060	0.67	0.10
2011-12-31	2012-01-03	1.6	17.0316	0.0132	0.57	0.05
2012-01-05	2012-01-12	5.2	17.1300	0.0060	0.80	0.10

Table I. Observing circumstances and lightcurve analysis results for specific date ranges. The columns are: starting date and ending date (yyyy-mm-dd) of the subset of data, solar phase angle, period and period error in hours, amplitude and amplitude error in magnitude.

Astrodon filter. The CCD was cooled to –30ºC. Images were corrected with dark frames and flat fields with the routines found in *MPO Canopus* (Warner, 2011) and then, with the same software, measured to produce the lightcurve data.

Phillips Academy Observatory used a 0.4-m *f*/8 DFM classsical Cassegrain and SBIG 1301E CCD with 1280x1024 20-micron pixels resulting in a plate scale of 1.00 arcseconds/pixel. The exposure time for the unguided images was 180 seconds through a clear filter. The CCD was cooled to –30ºC. All images were dark-subtracted and flat-field corrected. The processed images were measured with *MPO Canopus* (Warner, 2011). The Bassano Bresciano Observatory used a 0.32-m *f*/3.1Schmidt telescope and HX-516 CCD. Exposure times were 120 seconds through a clear filter. 2x2 binning was used for all images, resulting in a plate scale of 3 arcseconds/pixel. All images were flat-field and dark-frame corrected. The images were measured using *MPO Canopus* (Warner, 2011).

The combined lightcurve is shown in Figure 1. It consists of 48 sessions of *MPO Canopus* processed data. The individual lightcurves were adjusted so that, when available, the maximum portion of the lightcurves were lined up. Since we observed the asteroid from a solar phase angle of –22.48° (pre-opposition) through +10.48° (post-opposition), we have divided the data into six separate time intervals as shown in Figures 2-7. There is some variation in period and amplitude as a function of solar phase angle (Table I).

References

JPL Small-Body Database Browser (2012). *http://ssd.jpl.nasa.gov/sbdb.cgi*

Visual Information Solutions (2012). *http://www.exelisvis.com/ProductsServices/IDL.aspx*

Warner, B.D. (2011) MPO Software, Canopus version 10.4.0.6 Bdw Publishing, Colorado Springs.

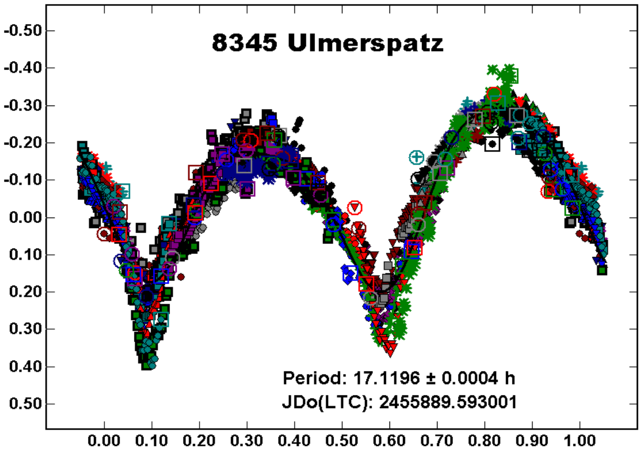


Figure 1. Lightcurve for 8345 Ulmerspatz using all data.

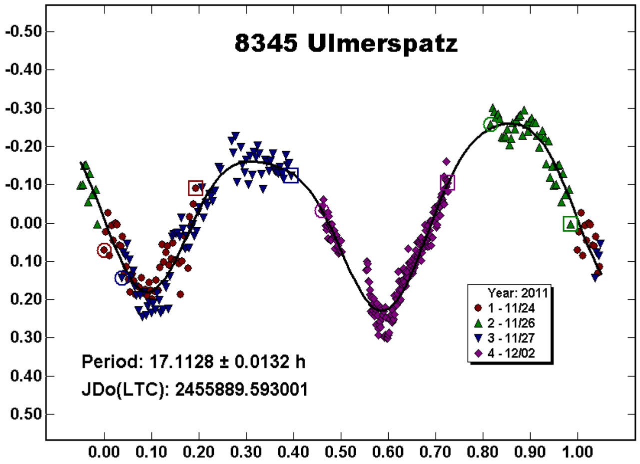


Figure 2. Lightcurve for 8345 Ulmerspatz, 2011 Nov 24 – Dec 2.

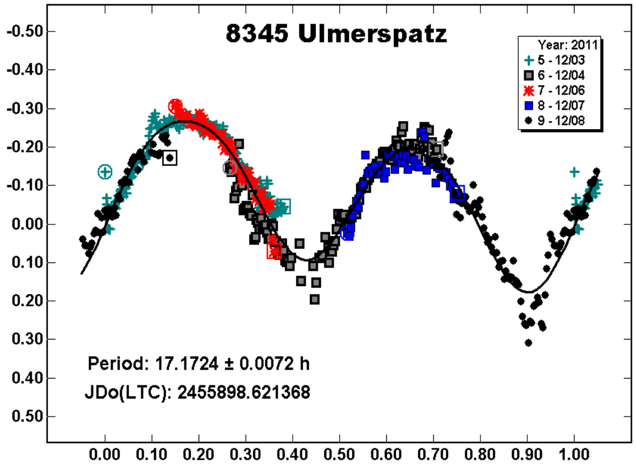


Figure 3. Lightcurve for 8345 Ulmerspatz, 2011 Dec 2 - 8.

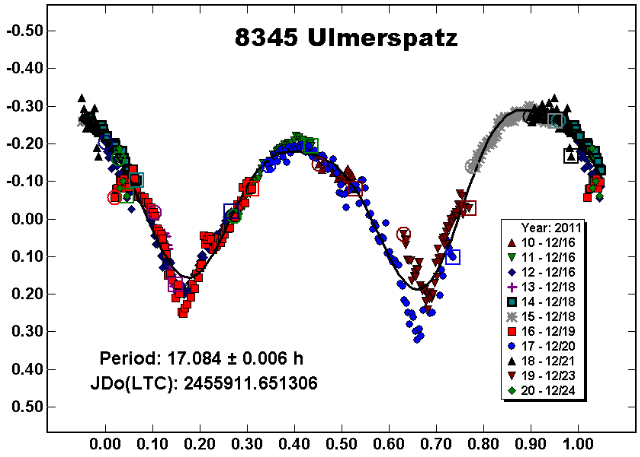


Figure 4. Lightcurve for 8345 Ulmerspatz, 2011 Dec 16 – 24.

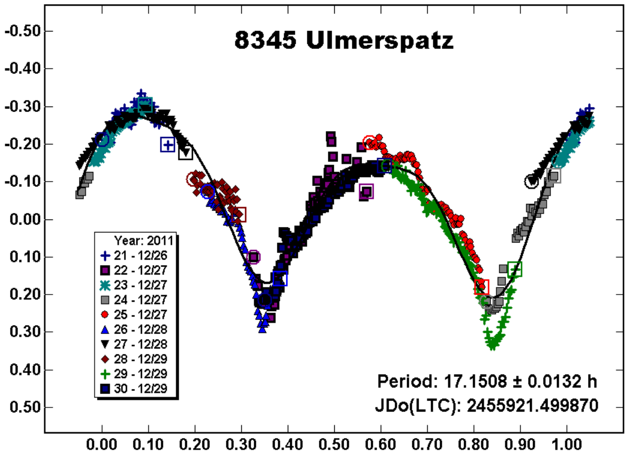


Figure 5. Lightcurve for 8345 Ulmerspatz, 2011 Dec 26 – 29.

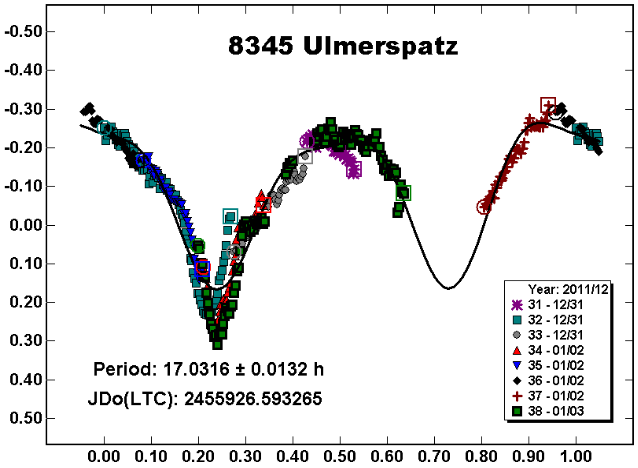


Figure 6. Lightcurve for 8345 Ulmerspatz, 2011/12 Dec 31 – Jan 3.

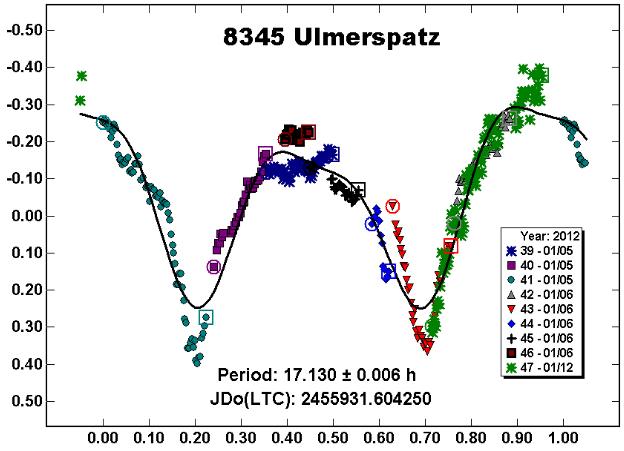


Figure 7. Lightcurve for 8345 Ulmerspatz, 2012 Jan 5 – 12.

LIGHTCURVES OF 2423 IBARRURI AND 8345 ULMERSPATZ

Robert K. Buchheim
Altimira Observatory (G76)
18 Altimira, Coto de Caza CA 92679 USA
Bob@RKBuchheim.org

(Received: 21 June)

The synodic lightcurve period of 2423 Ibarruri is found to be 139.89 ± 0.03 h. The synodic lightcurve period of 8345 Ulmerspatz is found to be 17.14 ± 0.02 h. For 8345 Ulmerspatz, phase curve parameters are also determined: H = 13.75 ± 0.03, G = –0.14 ± 0.02.

The synodic rotation rates for 2434 Ibarruri and 8345 Ulmerspatz were determined from the analysis of CCD photometric observations at the Altimira Observatory. In addition a comparison of results was made when using the MPOSC3 (Bdw Publishing) or the APASS (Henden *et al*., 2012) catalogs.

2423 Ibarruri. This asteroid was studied with differential photometry at Altimira Observatory (G76), using a 0.28-m Schmidt-Cassegrain (SCT) and SBIG ST8-XE CCD imager with photometric B, V, and R-band filters. The general observing cadence was R-R-V-V-B-B-... throughout each night in order to provide nearly simultaneous multi-color photometry. Images were reduced in the standard way with dark, flat, and bias frames. Comparison stars were chosen for near-solar color index with the “comp star selector” of *MPO Canopus;* all photometric reductions were also done with *MPO Canopus*. Because of the low signal-to-noise ratio, B-band images are not used for this report.

A total of 15 nights (separated by intervals of bad weather) from 2011-10-09 to 2011-11-17 UT were devoted to this asteroid, encompassing solar phase angles from α ~ –9.1° to α ~ +18.4°. There were no indications of changes in the lightcurve shape over this range of solar phase angles but the gaps in the phased lightcurve may be hiding some “shadowing” effects. The resulting lightcurve, phased to the best-fit period *P* = 139.89 h is shown in Figure 1. This is based on V-band data only, but there is no evidence of changing color index with rotational phase when the R-band data are included. The color index was determined to be V-R = 0.43 ± 0.03. This result confirms the period found by Ferrero (2012). My data do not display a plausible lightcurve when phased to the alternate period (*P* ~ 73 h) suggested by Vander Haagen (2012).

8345 Ulmerspatz

This project had two objectives: to take advantage of the favorable apparition of 8345 Ulmerspatz to determine its lightcurve and phase curve; and to use the recently-released APASS photometric catalog to determine comp star magnitudes.

Images were made at Altimira Observatory, predominantly unfiltered (“C-band”). A few R- ,V- and B-band images were taken on most nights but they are not shown in this report because of their low signal-to-noise ratio. Images were gathered on 14 nights spanning the interval 2011-12-26 through 2012-02-24 UT. This interval covered solar phase angles from α ~ –2.3°, to a minimum of α ~ 0.2°, and then continued to α ~ +27.6°.

APASS Catalog. The southern California weather during this project did not provide any clear/steady/stable nights suitable for calibration of comp star magnitudes. Data Release 6 of the AAVSO's APASS photometric catalog (Henden, *et al*., 2012) contains accurate V-band photometry for all of the comp stars used on all nights of this project. The APASS V-band magnitudes were inserted into the comp-star data blocks of *MPO Canopus* to put the differential photometry onto a standard baseline. There is, of course, a danger in using V-band magnitudes with C-band images. However, since the asteroid color and the comp-star colors are all nearly the same, the risk of differential-color effects is low. In addition, previous experiments with the Altimira Observatory equipment to measure the "C to V" transform (using Landolt standard stars) have shown that the C-to-V conversion is surprisingly good over a fairly wide range of (B-V) color.

Examination of the APASS photometry for the comp stars showed that the *MPO* "comp star selector" does a fine job of selecting stars with near-solar color. The APASS-reported B-V colors of the 70 comp stars used for this project averaged $\text{B-V}_{\text{avg}} = 0.67 \pm 0.10$ (std dev). The correlation between APASS V and MPOSC V magnitudes is also very good: the standard deviation of $[\text{V}_{\text{APASS}} - \text{V}_{\text{MPOSC}}]$ was about $\sigma \sim 0.11$, which is comparable to the original design specifications for the MPOSC. So, the MPOSC V-magnitudes are generally reliable. The key features of using the APASS photometry (rather than the MPOSC magnitudes) are (a) APASS magnitudes are actually measured in V, instead of being based on a correlation between IR magnitudes and B-, V-, R-magnitudes; (b) the accuracy of APASS magnitudes can be assessed for each individual star – generally ±0.05 mag or better for the stars used here – whereas the MPOSC accuracy can only be assessed statistically across the entire catalog; and (c) the use of APASS magnitudes corrects the few stars for which MPOSC V-magnitudes seem discordant.

The downside of using APASS is that each query of the catalog will only search a small field (less than a few degrees diameter). This means that each night's set of comp stars requires a separate query of the APASS database. Each query returns the data on all of the stars in the requested field; then the output table must be searched to find the comp stars that were used. It's a bit cumbersome, but the confidence in comp star magnitudes makes it worth the effort for determining the phase curve of an asteroid.

Lightcurve. There are two reports of lightcurves and periods for this asteroid 8345: Klinglesmith (2012) reported *P* = 17.12 h and Strabla *et al*. (2012) reported *P* = 17.416 h. Both of these are based on data taken at the same apparition as the present study. If only the nights with low solar phase angle ($-3° < \alpha < +4°$) are considered, a nice double-peaked lightcurve is found, as shown in Figure 2, with a best-fit synodic period *P* = 17.13 ± 0.02 h. The shape of this lightcurve is essentially identical to that seen by Klinglesmith (2012).

At large solar phase angle ($\alpha > 18°$) after opposition, the shape of the lightcurve changed dramatically, having much deeper primary and secondary minima, as shown in Figure 3. This is presumably a shadowing effect, which suggests a complex shape for this object.

Phase curve. The phase curve was determined based on the APASS V-magnitudes of the comp stars, using the method developed by Harris *et al*. (1989). The resulting phase curve, describing the peak brightness of the rotational lightcurve as a function of solar phase angle, is shown in Figure 4. The best-fit parameters are: $H = 13.75 \pm 0.03$; $G = -0.14 \pm 0.02$. These parameters, and the curve shown, exclude the data from 2012-02-24 (phase angle $\alpha = 27.6°$) because the short interval of observations that night and the changing shape of the lightcurve at large solar phase angle made it unreliable to extrapolate the peak brightness of the lightcurve. The negative slope parameter is somewhat unusual, but similar results have been reported before, e.g. Lagerkvist and Williams (1987), Harris (1989), and Warner (2007).

The data gathered by Strabla et al (2012) and posted on ALCDEF also captured the night of minimum solar phase angle, and so offered a valuable check on the phase curve. Their comp star magnitudes were taken at face value, except for the night of UT 2012-01-12, on which their comp star magnitudes were noticeably different from the APASS V-magnitudes for the indicated star. Applying the APASS magnitudes for the comp stars on that night (but making no change to Strabla's other nights), and combining their data with mine, yielded the phase curve shown in Figure 5, which is characterized by $H = 13.76 \pm 0.02$ and $G = -0.13 \pm 0.02$, within the stated errors of the values reported here.

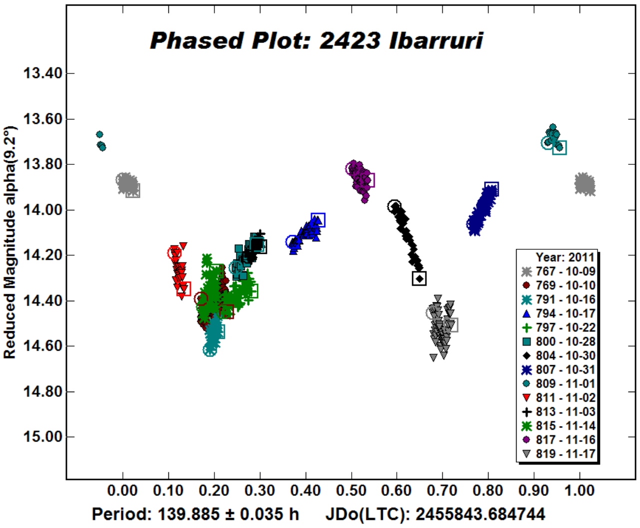


Figure 1: Lightcurve of 2423 Ibarruri in V-band, phased to 139.89 h.

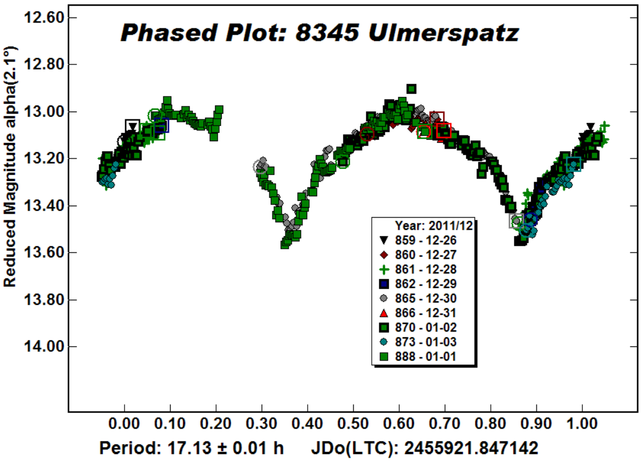


Figure 2: Lightcurve of 8345 Ulmerspatz at low solar phase angle, phased to P = 17.13 h.

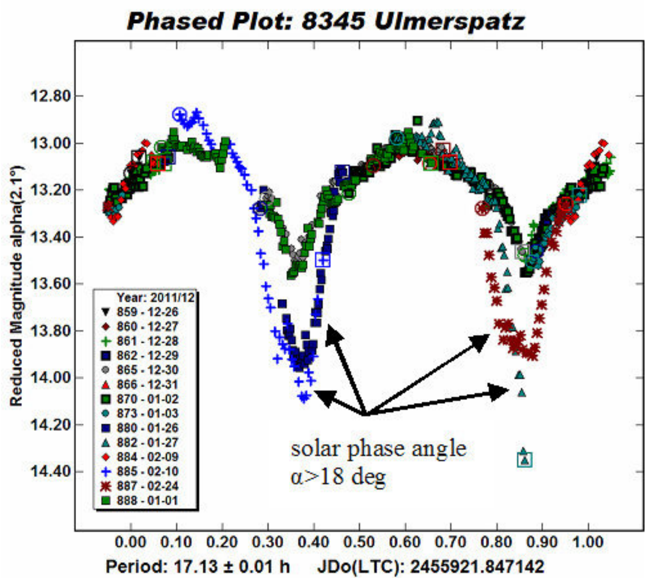


Figure 3: Lightcurve of 8345 Ulmerspatz, phased to P = 17.13 h, showing the dramatic increase in amplitude at large solar phase angles (α > 18°), presumably caused by shadowing of a complex surface.

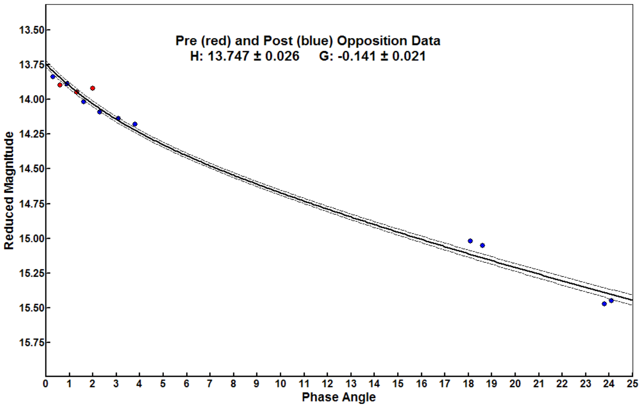


Figure 4: Phase curve of 8345 Ulmerspatz, based on data from Altimira Observatory (this study), with best-fit slope parameter G = –0.14.

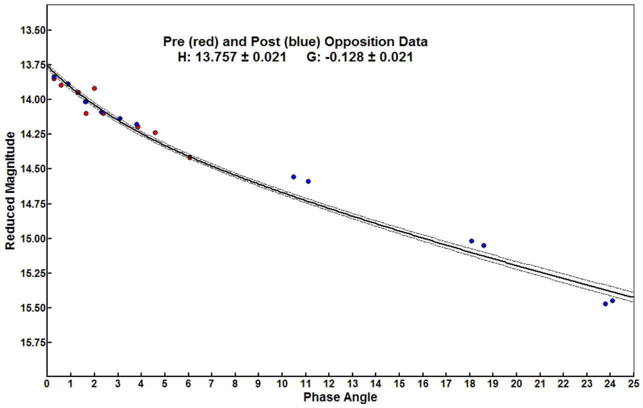


Figure 5: Phase curve of 8345 Ulmerspatz, combining data from this study with Strabla's data (from the same apparition) as posted on ALCDEF, giving consistent H and G parameters.

Acknowledgements

This research made use of the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund. This research made use of the ALCDEF database maintained by the Minor Planet Center. I thank Mr. Luca Strabla and the Bassano Bresciano Astronomical Observatory for making their lightcurve data publically available on the ALCDEF database.

References

Ferrero, Andrea (2012). "Lightcurve Determination at the Bigmuskie Observatory from 2011 July- December." *Minor Planet Bulletin* **39**, 65.

Harris, A.W. (1989). "The H-G Asteroid Magnitude System: Mean Slope Parameters," in: *Abstracts of the Lunar and Planetary Science Conference* **20**, 375.

Harris, A.W., Young, J.W., Contreiras, L., Dockweiler, T., Belkora, L., Salo, H., Harris, W.D., Bowell, E., Poutanen, M., Binzel, R.P., Tholen, D.J., and Wang, S. (1989). "Phase Relations of High Albedo Asteroids. The unusual opposition brightening of 44 Nysa and 64 Angelina." *Icarus* **81**, 365-374.

Henden, A H., Smith, T.C., Levine, S.E., and Terrell, D. (2012). "The AAVSO Photometric All-Sky Survey Completes the Sky", *AAS 220* meeting, Anchorage AK, June 2012.

Klinglesmith, D. A., Odden, C., and Ferrerro, A. (2012). unpublished results on website: *www.andover.edu/Academics/NaturalSciences/Observatory/Pages/Scientific-Research.aspx*

Lagerkvist, C.-I. and Williams I.P. (1987). "Physical Studies of Asteroids XV: Determination of Slope Parameters and Absolute Magnitudes for 51 Asteroids." *Astronomy & Astrophysics Supplement Series* **68**, 295-315.

Strabla, L., Quadri U., and Girelliet R. (2012). "Lightcurve Analysis for Eight Minor Planets at Bassano Bresciano Observatory." *Minor Planet Bulletin* **39**, 177.

Vander Haagen, G.A. (2012). "Lightcurves Of 724 Hapag, 2423 Ibarruri, 4274 Karamanov, 4339 Almamater, and 5425 Vojtech." *Minor Planet Bulletin* **39**, 48.

Warner, Brian D. (2007). "Initial Results from a Dedicated H-G Project." *Minor Planet Bulletin* **34**, 113-119.