

PHOTOMETRY OF ASTEROID 706 HIRUNDO AUGUST AND SEPTEMBER 2000

Bill Holliday
1125 Isaac Creek Circle
New Braunfels, Tx. 78132
holliday@satx.net

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Asteroid 706 Hirundo was chosen for observation to determine its lightcurve period and to check its H magnitude. The lightcurve was analyzed with Tycho 2 stars to check their suitability as primary references for lightcurve work. The resulting curve exhibited a period of 22.00 hours and an amplitude of 0.75 magnitudes. The Tycho 2 stars were barely adequate as references. H was determined to be 11.0 magnitude.

Asteroid 706 Hirundo was chosen from the "CALL" web site List of Potential Lightcurve Targets (Warner 2000). Hirundo was observed on the dates 8/26, 8/27, 8/28, 8/31, 9/2, 9/3, 9/4, 9/8, 9/10, and 9/11/00 Universal Time through phase angles of 2.4 to 7.2 degrees. The many nights of observation yielded only one period solution of 22.00 hours with an uncertainty constrained to 0.025 hours. All images were taken through a V photometric filter. Master dark and flat fields were used. The telescope was a 0.40 meter Newtonian. Tycho 2 star Vt magnitudes were converted to V magnitudes and their uncertainties from both magnitude and color recorded. The asteroid's V instrumental magnitude was converted to the standard system using a transformation for this telescope-camera system. Single night lightcurves were converted to reduced magnitudes at zero phase angle using a phase coefficient of 0.2 in constructing the composite curve. The curve has a best fit for a 22.00-hour period with an uncertainty of 0.025 hours. The full amplitude of the lightcurve was observed to be 0.75 magnitudes this opposition.

Considerable adjustment to the recorded magnitudes were needed for data on the nights of 8/28, 9/3 and 9/4 due to the large

uncertainties in the Tycho 2 catalog magnitudes for stars used those nights. (See table I.) The Tycho star with the lowest uncertainty of 0.022 magnitudes which was used on the nights of 9/3 and 9/4/00 became the primary reference star. The curve was fitted to that star and since the data were corrected to standard V and reduced to zero phase angle, the H magnitude should be the midpoint of the curve. This opposition H appears to be about 11.0, dimmer than the 10.2 recorded in the literature from previous oppositions.

Acknowledgments:

The uncertainties in the Tycho 2 catalog (Table I.) were obtained from a Strasburg web site referred to the author by Brian Skiff at Lowell Observatory via e-mail. Corrections to the Tycho magnitudes were from the Bessell Conversion table, referred to the author by both Brian Skiff and Arne Henden. In Table I the Tycho 2 stars are listed only by their Guide Star Catalog names. Magnitude conversions to reduced magnitude at zero phase angle were done with math contained in Batrakov (1992) which referenced the Minor Planet Circulars #10193 and 10194. Correction of instrumental magnitude to standard system was done with methods outlined in Henden & Kaitchuck (1982) and with Pleides stars also referenced in same.

References:

- Batrakov, Y.V. (1992). *Ephemerides of Minor Planets*
- Henden, A.A. and Kaitchuck, R.H. (1982). *Astronomical Photometry*. Willman-Bell, Richmond Va.
- Warner, B. (2000). "Potential Lightcurve Targets". <http://www.minorplanetobserver.com/astlc/targets>.
- Bessell, M. S. (2000) "The Hipparcos and Tycho Photometric Passbands". *Astron. Soc. Pac.* 112, p961-965
- VisieR Catalog search, Centre De Donnees Astronomiques De Strasbourg, <http://visier.u-strasbg.bg.fr/cgi-bin/VisieR>

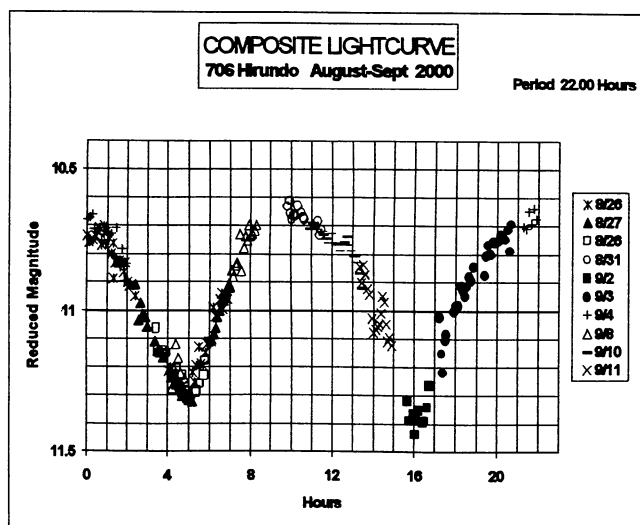


Figure 1. 706 Hirundo Lightcurve

Table I. Tycho 2 star uncertainties

706 references

date	GSC name	corrected B-V	corrected V	catalog V uncertainty	shift needed
8 26	5236:537	0.505	10.681	0.09	0
8 27	5236:537	0.505	10.681	0.09	0
8 28	5229:1494	0.891	11.509	0.269	0.2
8 31	5229:1405	0.845	10.119	0.103	0
9 2	5229:1263	0.454	9.842	0.065	-0.03
9 3	5229:418	1.078	8.388	0.022	0
9 4	5229:418	1.078	8.388	0.022	0
9 8	5228:1265	0.582	10.411	0.095	0
9 10	5228:1114	0.332	11.002	0.17	-0.25
9 11	5228:1114	0.323	11.012	0.17	-0.22

COLLABORATIVE LIGHTCURVE PHOTOMETRY OF ONE MARS-CROSSING AND TWO MAIN BELT ASTEROIDS

Robert A. Koff
1915 W. 101st Avenue
Thornton, CO 80260 USA
Bob.Koff@worldnet.att.net

Stephen M. Brincat
FL5 Ent.B, Silver Jubilee Apt.,
Ta' Zwej, San Gwann SGN 09, Malta
sbrincat@orbit.net.mt

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Overcoming the 24 hour commensurability of the Earth's rotation for mid-latitude observatories requires multiple sites widely separated in longitude. In addition, collaboration is useful in general due to differences in weather patterns and observing opportunities, as well as for relatively long-period asteroids. We report an ongoing collaborative lightcurve investigation between Thornton Observatory in the United States and Flarestar Observatory in Malta (separated in longitude by 119 degrees). Asteroid (713) Luscinia was determined to have a period of 9.703 ± 0.006 hours and an amplitude of $0.54 \text{ mag} \pm 0.05$ magnitude. Mars-crossing asteroid 2000 OL was found to have a period of $3.136 \text{ hours} \pm 0.003 \text{ hours}$, with an amplitude of $0.30 \text{ magnitude} \pm 0.04 \text{ magnitude}$. Asteroid (535) Montague was found to have a period of $10.28 \text{ hours} \pm 0.01 \text{ hours}$, with an amplitude of $0.24 \text{ magnitude} \pm 0.03 \text{ magnitude}$.

Equipment and Procedures

Thornton Observatory is located in Thornton, Colorado, at an elevation of 5530'. Since 1997, the observatory, operating as Minor Planet Center observatory code 713, has been performing asteroid astrometry and photometry.

Flarestar Observatory is located in San Gwann, Malta at an altitude of 300 feet. In 1999, Flarestar started operation as Minor Planet Center observatory code 171 and has been performing asteroid astrometry and photometry. Details of both observatories equipment may be found in Koff and Brincat (2000).

Targets were selected based on their magnitude and position in the sky, to maximize the length of time they would be observable, particularly under the restricted sky visibility of Thornton Observatory. Targets were selected for which no lightcurve data had been previously reported, or for which only uncertain data was available (Harris, 1997). The images were obtained in unfiltered light, with the exception of one night's observations from Thornton of 713 Luscinia using an R filter. Differential photometry was performed using the program "Canopus" by Brian Warner, which uses aperture photometry. Magnitudes were calculated using reference stars from the LONEOS catalog. The same reference stars were used by each observatory, but comparison stars differed from night-to-night due to movement of the asteroid. Lightcurves were prepared using "Canopus", based on the method developed by Dr. Alan Harris (Harris et al, 1989). This program allows compensation for night-to-night comparison

star variation by manually shifting individual night's magnitude scales to obtain a best fit. Such adjustment is especially necessary when combining data from two observatories using cameras with different spectral sensitivities.

Observations and Results

713 Luscinia

Luscinia, a main-belt asteroid, was observed initially by Thornton Observatory on June 21, 2000. Observations from Thornton were made on 4 nights during the period from June 21, 2000 to July 1, 2000. Exposure times at Thornton for these investigations were four minutes each. Images were taken at 10-minute intervals. Dark frames and flat fields were used to calibrate each image. At Flarestar, observations were made on two nights, on June 21-22, 2000 and June 27-28, 2000. Exposure times were 90 seconds each at an average interval of six minutes. Images were calibrated with dark frames and flat field frames. Observations made at Thornton on June 22 were made using an R filter. The individual lightcurve sessions for 713 were shifted in magnitude scale to align with the data taken with the R filter. The magnitude calibration for the R filter observations were derived by comparison with stars from the LONEOS reference catalog, which lists stars with magnitude accuracies within 0.05 magnitude (Skiff 2000). A total of 140 images were made, of which 101 were used in the solution.

Figure 1 shows the resulting lightcurve. The zero point of the curve is J.D. 2451716.6687. The period was determined to be $9.703 \text{ hours} \pm 0.006 \text{ hours}$, with an amplitude of 0.54 ± 0.05 . The mean measured magnitude was 13.45 R.

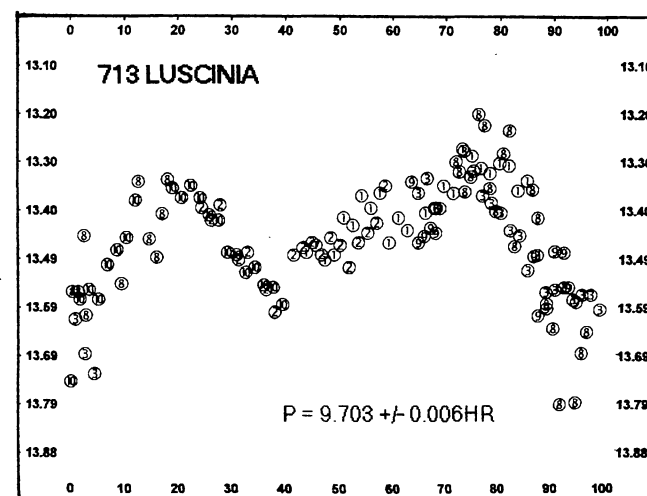


Figure 1. Lightcurve of 713 Luscinia, based on a period of 9.703 hours $\pm$ 0.006 hours. Ordinate is R magnitude. Curves 8 (6/21/2000) and 9 (6/27/2000) are Flarestar observations. Curves 10 (6/21/2000), 1 (6/22/2000), 2 (6/30/2000) and 3 (7/1/2000) are Thornton observations.

2000 OL

Mars-Crossing asteroid 2000 OL (perihelion distance = 1.34 AU) was observed initially by Thornton Observatory on July 27, 2000. At the time, the newly-discovered object was on the NEO Confirmation Page of the Minor Planet Center, and was designated as G70139. At the conclusion of the astrometric session, observations were extended to attempt to detect