

BROAD-BAND PHOTOMETRIC MONITORING OF 2500 ALASCATTALO

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Broad-band photometric monitoring of the stony asteroid 2500 Alascattalo was carried out over three nights in 2023 February. We find a typical color of $V-R = 0.44 \pm 0.05$ mag, which is in good agreement with expectations for S-class asteroids. We also report a rotation period of 2.751 ± 0.001 h and a V-band variability amplitude of 0.16 ± 0.02 mag, which are in excellent agreement with previously reported measurements.

2500 Alascattalo was discovered on 1926 April 2 by Karl Wilhelm Reinmuth at the Heidelberg Observatory (JPL, 2023). It is a member of the Flora family of stony asteroids in the innermost asteroid belt, and the collision that formed the Flora family is possibly the source of many large asteroids that impacted the Earth during the mid-Proterozoic era (Vokrouhlický et al., 2017). Recently, 2500 Alascattalo was found to have a satellite that is roughly 40% its diameter (Benishek et al., 2020), making it a binary asteroid system.

Observations of 2500 Alascattalo were obtained as part of the course work for the Georgia State University class *Astronomical Techniques and Instrumentation* at GSU's Hard Labor Creek Observatory in Rutledge, GA. Monitoring was carried out with the 24-inch Miller Telescope, an $f/6.5$ Planewave Corrected Dall-Kirkham Astrograph, equipped with an FLI ProLine CCD with 2048×2048 pixels, giving a field of view of 26.3 arcmin $\times$ 26.3 arcmin and a pixel scale of 0.77 arcsec. Images through the Johnson-Cousins R filter were collected on UT date 2023 Feb 4 under bright Moon conditions, with a typical exposure time of 300 s for each of the 50 good frames. Darker skies were present when observations through the Johnson V filter were collected on UT date 2023 Feb 18, with each of the 67 frames acquired with a typical exposure time of 300 s, and on UT date 2023 Feb 20, with 31 frames acquired using a typical exposure time of 240 s.

All images were reduced in IRAF following standard procedures, which included bias and overscan subtraction, dark subtraction, and flat fielding. Aperture photometry of the asteroid and 6-7 field stars was carried out in IRAF. APASS V -band photometry of field stars (Henden et al., 2008) was used to convert instrumental V

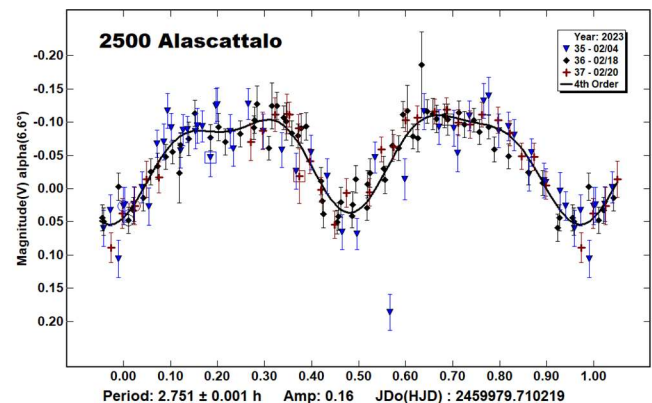
magnitudes to calibrated V magnitudes, while the transformation equations of Jordi et al. (2006) for Population I stars were used to determine the effective R magnitudes for field stars, and thus the asteroid, using the Sloan r' magnitudes and the $g'-r'$ colors from APASS. We find a typical color for 2500 Alascattalo of $V-R = 0.44 \pm 0.05$ mag. This color agrees well with the expected value 0.475 for stony, or S-type, asteroids (Dandy et al., 2003).

The rotation period and variability amplitude of the asteroid were determined using *MPO Canopus*, which implements the Fourier Analysis of Light Curves (FALC) algorithm of Harris et al. (1989). A rotation period of 2.751 ± 0.001 h and a variability amplitude of 0.16 ± 0.02 mag was determined by offsetting the R -band light curve to match the V band and then fitting both bands simultaneously. Given the lower signal-to-noise of the R -band measurements (blue triangles in the figure below) due to the nearly full Moon on that night, we also fit each band separately:

V : rotation period = 2.751 ± 0.001 h, amplitude = 0.16 ± 0.02 mag.

R : rotation period = 2.786 ± 0.050 h, amplitude = 0.18 ± 0.02 mag.

While the uncertainties are larger for the period and amplitude derived from the R -band measurements, the results of analyzing each band separately agree with the results derived from fitting both bands together. Our reported rotation period agrees extremely well with previous findings, which include 2.754 ± 0.007 h (Behrend, 2013web), 2.751 ± 0.002 h (Liu, 2016), and 2.75123 ± 0.00009 h (Benishek et al., 2020). The observations we describe here appear to be the first filtered observations of 2500 Alascattalo, but we find a similar amplitude of variability as reported by these earlier studies through a clear filter.



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Number	Name	2023 mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2500	Alascattalo	02/04-02/20	*6.61, 8.53	140	10	2.751	0.001	0.16	0.02	402

Table 1. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

References

- Benishek, V.; Pravec, P.; Pilcher, F.; Marchini, A.; Papini, R.; Salvaggio, F.; Oey, J.; Pray, D.; Durkee, R.; Cooney, W.; Gross, J.; Terrell, D.; Gonçalves, R.; Aznar, A.; and 2 colleagues. (2020). "(2500) ALASCATTALO." *CBET* **4791**.
- Behrend, R. (2013web). Courbes de rotation d'astéroïdes et de comètes. http://obswww.unige.ch/~behrend/page_cou.html
- Dandy, C.L.; Fitzsimmons, A.; Collander-Brown, S.J. (2003). "Optical colors of 56 near-Earth objects: trends with size and orbit." *Icarus* **163**, 363-373.
- Harris, A.W.; Young, J.W.; Scaltriti, F.; Zappala, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gytis." *Icarus* **57**, 251-258.
- Harris, A.W.; Young, J.W.; Bowell, E.; Martin, L.J.; Millis, R.L.; Poutanen, M.; Scaltriti, F.; Zappala, V.; Schober, H.J.; Debehogne, H.; Zeigler, K.W. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.
- Henden, A.A.; Terrell, D.; Levine, S.E.; Templeton, M.; Smith, T.C.; Welch, D.L. (2009). "APASS: The AAVSO Photometric All-Sky Survey." <http://www.aavso.org/apass>
- Jordi, K.; Grebel, E.K.; Ammon, K. (2006). "Empirical color transformations between SDSS photometry and other photometric systems." *Astron. Astrophys.* **460**, 339-347.
- JPL (2023). "Small-Body Database Browser." https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html
- Liu, J. (2016). "Rotation Period Analysis for 2500 Alascattalo." *Minor Planet Bull.* **43**, 111.
- Vokrouhlický, D.; Bottke, W.F.; Nesvorný, D. (2017). "Forming the Flora Family: Implications for the Near-Earth Asteroid Population and Large Terrestrial Planet Impactors." *Astron. J.* **153**, 172.
- Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2023 April. <http://www.MinorPlanet.info/php/lcdb.php>

LIGHTCURVES AND ROTATION PERIODS OF 111 ATE, 169 ZELIA, 421 ZAHRINGIA, AND 580 SELENE

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Synodic rotation periods and amplitudes at their early 2023 oppositions are found for 111 Ate 22.068 ± 0.001 hours, 0.11 ± 0.01 magnitudes; 169 Zelia 14.539 ± 0.001 hours, 0.17 ± 0.01 magnitudes; 421 Zahringia 25.509 ± 0.002 hours, 0.14 ± 0.01 magnitudes; 580 Selene 9.494 ± 0.001 hours, 0.19 ± 0.01 magnitudes.

The new observations to produce the results reported in this paper were made at the Organ Mesa Observatory with a Meade 35 cm LX200 GPS Schmidt-Cassegrain, SBIG STL-1001E CCD, 60 to 120 second exposures, unguided, R filter for 11th magnitude 111 Ate, clear filter for all other targets. Image measurement and lightcurve construction were with *MPO Canopus* software with calibration star magnitudes for solar colored stars from the CMC15 catalog reduced to the Cousins R band. Zero-point adjustments of a few $\times 0.01$ magnitude were made for best fit. To reduce the number of data points on the lightcurves and make them easier to read, data points have been binned in sets of 3 with maximum time difference 6 minutes.

111 Ate. Previously published rotation periods for 111 Ate are by Harris and Young (1983), 22.2 hours; Behrend (2006web), 20 hours; Pilcher (2010), 22.072 hours; Pilcher (2011), also 22.072 hours; Szabó et al. (2016), 20.63 hours; Pál et al. (2020), 22.0497 hours. New observations on 8 nights 2023 Jan. 27 - March 10 provide an excellent fit to a lightcurve with period 22.068 ± 0.001 hours, amplitude 0.11 ± 0.01 magnitudes and four unequal maxima and minima per rotational cycle. This value is in good agreement with most of the previously found periods.

