

LIGHTCURVE AND ROTATION PERIOD ANALYSIS OF 1908 POBEDA, 2168 SWOPE, AND 5203 PAVAROTTI

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Photometric observations were made of asteroids 1908 Pobeda, 2168 Swope, and 5203 Pavarotti. From these, we determined the synodic rotation period and lightcurve amplitudes for each asteroid.

CCD photometric observations were obtained by observatories around the globe from 2024 March to June for asteroid 1908 Pobeda and from 2024 August to September for asteroids 2168 Swope and 5203 Pavarotti. Several of the co-authors used their own equipment and some used the Las Cumbres Observatory facilities.

The photometric analysis was performed using *TychoTracker Pro* Version 11.7.5 (TT; Parrott, 2024). Standard differential techniques were used on images with the comparison stars selected by TT to be within the colour range of $+0.50 < (B-V) < +0.90$, i.e., near solar color. The Asteroid Terrestrial-impact Last Alert System catalog (ATLAS refcat2; Tonry et al., 2018), was used as the source of magnitudes for the comparison stars.

Period determination in TT operates by using user-defined orders of Fourier analysis to find model lightcurves by sampling periods over a user-defined range that best fit the data. The program lists the RMS of the fit for each sample period and uses the values to create a *period spectrum*, which plots RMS versus period. Each object yielded a clear best-fit solution, seen as a well-defined minimum RMS in the period spectrum. In some cases, datapoints used for analysis were created by combining (binning) raw data points in order to improve the signal-to-noise ratio.

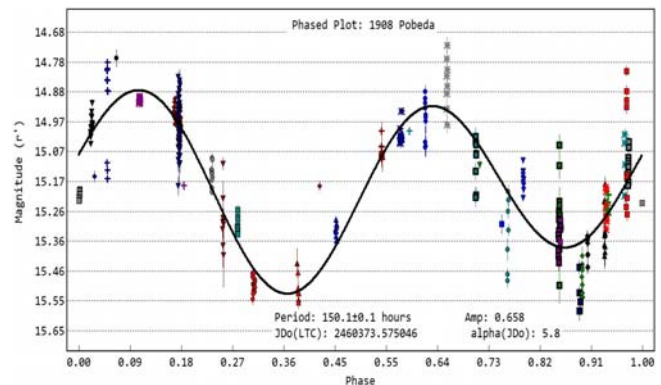
The period spectra often exhibit several possible periods, in which case an examination of the rotational phase plot for each of these periods is then conducted to look for a credible lightcurve. Where the object shape is the dominant factor in producing the observed magnitude changes, and especially if the lightcurve amplitude is on the order of >0.2 mag, a bimodal lightcurve, meaning two minimum/maximum pairs per cycle, was usually chosen as the most likely solution. The results are summarized in the Table 1.

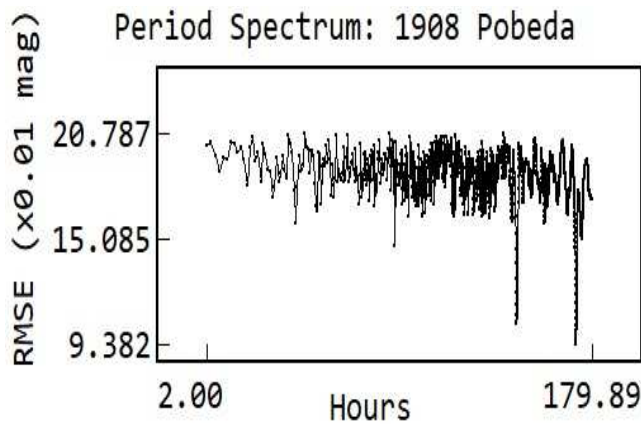
In this paper, no attempt is made to find an absolute magnitude (H) or phase slope parameter (G). Instead, we used a default value of $G = 0.15$ throughout the calculations. Time-series magnitude estimates from different nights and observing locations using a variety of imaging equipment were offset in magnitude to bring them into alignment when producing the raw and rotational-phase plots. The same offset was used for each instance of an individual imaging setup.

All the data will be uploaded into the Asteroid Lightcurve Data Exchange Format (ALCDEF) database (<https://alcdef.org>) following publication.

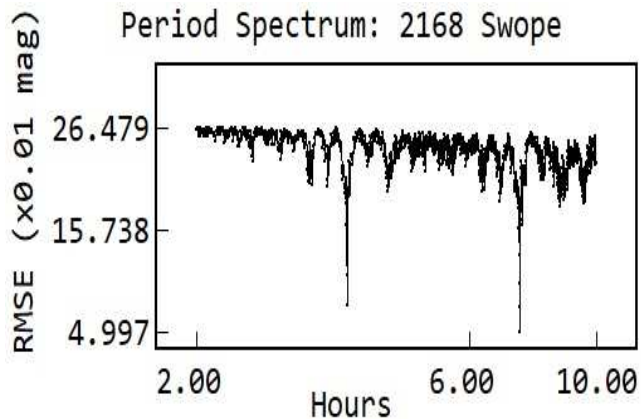
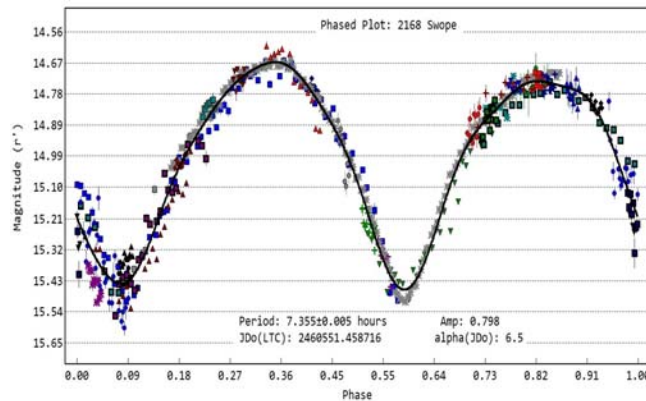
Information given for an object is taken from the NASA Jet Propulsion Laboratory (JPL, 2023) Small-Body Database Lookup webpage.

1908 Pobeda is an outer main-belt asteroid that was discovered on 1972 Sep 11 by N. Chernykh at Nauchnyj. Our data set of 39 observing sessions (404 data points) was obtained between 2024 March and June. Analysis of the data found a synodic period of 150.1 ± 0.1 h; this compares well with the sidereal period of 149.95 h from Durech et al. (2020). The peak-to-peak amplitude of the lightcurve is 0.66 ± 0.09 mag.

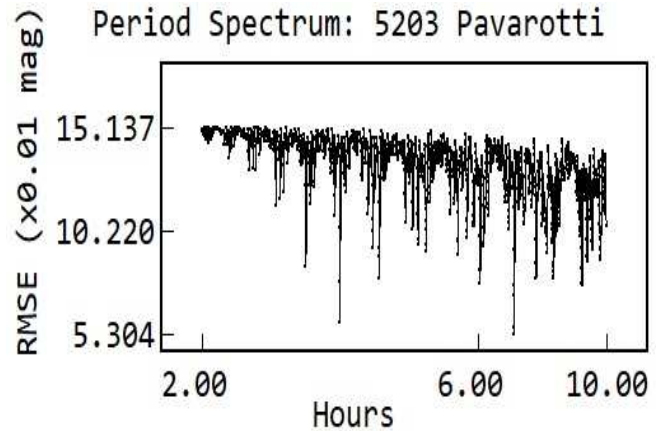
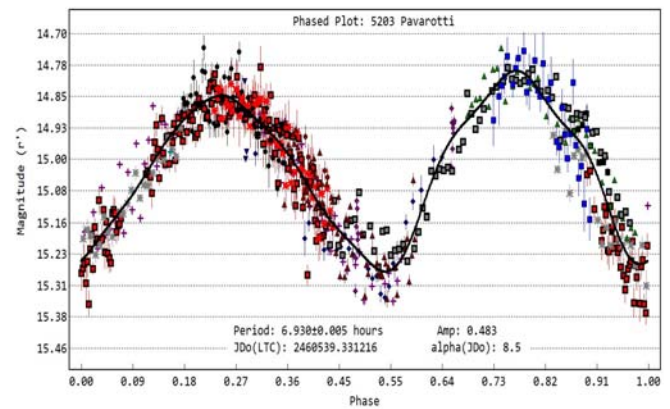




2168 Swope. This is an inner main-belt asteroid discovered on 1955 Sep 14 at Goethe Link Observatory in Brooklyn. It is named after Henrieta Hill Swope, an American astronomer who studied variable stars, particularly the period-luminosity relationship of Cepheids. Our results are based on 31 observing sessions (603 exposures) obtained between 2024 August and September. Our bimodal lightcurve has a period of $P = 7.355 \pm 0.005$ h and amplitude of $A = 0.80 \pm 0.05$ mag.



5203 Pavarotti is an inner main-belt that was discovered on 1984 Sep. 27 by Zdeňka Vávrová, a Czech astronomer at the Kleť Observatory. Our results of $P = 6.930 \pm 0.005$ h and $A = 0.48 \pm 0.04$ mag are based on 15 observing sessions (668 exposures) obtained between 2024 August and September.



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The ATLAS refcat2 makes use of the formulae to convert Pan-STARRS gri to BVRI from Kostov and Bonev (2017).

This work makes use of observations from the Las Cumbres Observatory global telescope network.

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Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
1908	Pobeda	2024 03/04-06/18	*4.7, 21.3	179	1	150.1	0.1	0.66	0.09	9106
2168	Swope	2024 08/29-09/30	*2.4, 12.0	346	4	7.355	0.005	0.80	0.05	9104
5203	Pavarotti	2024 08/16-09/12	*2.3, 9.3	336	3	6.930	0.005	0.48	0.04	9104

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached a minimum 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).

Observatory	Telescope	CCD/CMOS	Filter	Object (sessions)
Hawley Old Orchard Observatory (Z09)	0.35-m SCT f/6.7	SX694 Trius Pro (2×2)	SR	1908 (7) 2168 (7) 5203 (5)
Wiggins University of Utah, (718)	0.35-m SCT f/5.5	ST-10XME (3×3)	C	1908 (19) 2168 (19)
Armstrong Sutherland LCO-Aqawan A (L09)	0.4-m f/8	SBIG STL6303 (1×1)	SR	2168 (1)
Armstrong McDonald LCO-Aqawan A (V38)	0.4-m f/8	SBIG STL6303 (1×1)	SR	5203 (1)
Leyland Tacande Observatory (J22)	0.4m Dilworth f/6.5	SX814 Trius Pro (2×2)	V	2168 (2) 5203 (3)
DeGross Whiskey Creek Observatory (V19)	0.46m Newt f/4.2	QHY 268M	V	2168 (1)
Arnold NNHS Drummonds Observatory (Z34)	0.3m f/3.8	SX694 Trius Pro	C	2168 (1)
Haymes Southside Observatory (Y98)	0.28m f/5.8	QHY 174	C	1908 (1) 5203 (1)
Kardasis Takoudi (5203) Pelagia-Eleni Observatory (247)	0.28m SCT f/10	ASI 183 Pro	V	1908 (8) 5203 (4)
Privett LPMR Observatory (Y82)	0.3m f/4	SX694 Trius Pro	C	1908 (1)
Genebriera Astropriorat Observatory (M02)	0.41m f/8	Moravian G4-16000	V	1908 (3)

Table II. List of observers, equipment, and sessions for each location.