

RESULTS OF THE 2016 MEXICAN ASTEROID PHOTOMETRY CAMPAIGN

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We report the results of the 2016 Mexican Asteroid Photometry Campaign. This year observers from seven different research institutions carried out 34 nights of observations at three Mexican observatories. An uncertain, but long, period of $\sim 115.108 \pm 0.014$ h was estimated for 703 Noëmi from sparse data. A nearly-complete lightcurve was obtained for 1305 Pongola ($P = 8.0585 \pm 0.0003$ h). Asteroid 2535 Hämeenlinna turned out to be a binary system where the primary exhibits a rotation period of 3.2311 ± 0.0001 h and the secondary shows an orbital period of 21.20 ± 0.004 h. Asteroid 4775 Hansen ($P = 3.1186 \pm 0.0001$ h) was well observed and showed variations of its lightcurve between two sets of observations separated by about six weeks.

After the successful start of the Mexican Asteroid Photometry Campaign in 2015 with the coordinated observation of three asteroids from three different Mexican observatories (Sada et al., 2016), it was decided to seek increasing the collaboration during 2016. The eventual goal of this effort is to develop teams of coordinated observers in México capable of characterizing not

only main-belt asteroids, but NEOs as well. We report here the results of the 2016 Mexican Asteroid Photometry Campaign.

On this occasion, we collected 34 nights of observations from three different observatories by researchers from seven different institutions. On three of those nights, the observing session was carried out simultaneously from two separate observatories, providing a basis for photometric comparison between them and prolonging the observing period for the target since the observatories were separated by more than 10° in longitude.

At the Universidad de Monterrey (UdeM) Observatory (MPC 720) we observed four asteroids on 17 different nights using a Meade 0.36-m $f/8$ LX600-ACF telescope and SBIG STL-1301E CCD. The camera uses a 1280×1024 -16 μm KAF-1301E/LE chip which covers a $\sim 26.3 \times 21.1$ arcmin field-of-view (FOV) with an image scale of about 1.24 arcsec/pix. All asteroids were observed unfiltered for maximum SNR and the CCD images were read in 2×2 binned format for faster download time and improved observing efficiency. The FOV was maintained fixed on the chip by using an on-axis guide star at all times. Exposure times varied between 60 s and 210 s for each night depending on the target's brightness; sometimes a slight defocus was applied to the telescope to spread the images over a few binned pixels allowing for slightly longer exposure times.

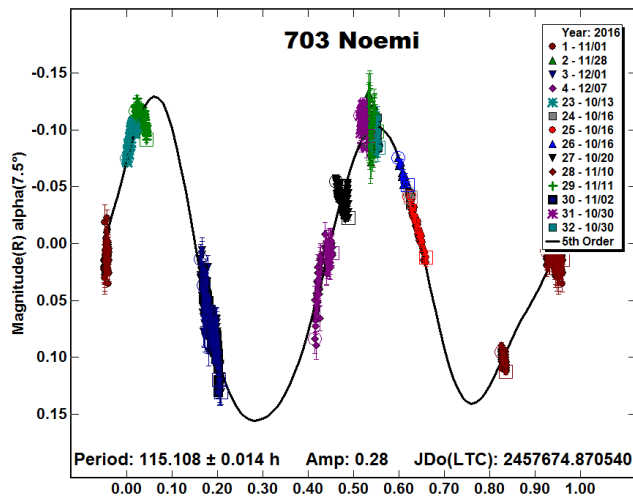
Three one-week observing runs were scheduled throughout the year with the 0.84-m $f/15$ Ritchey-Chretien telescope at the Observatorio Astronómico Nacional on the Sierra de San Pedro Mártir (OAN-SPM; MPC 679) in Baja California for this program. On top of that, a few additional partial nights of observations were attained on an availability basis from other observing runs. This telescope uses a 2048×2048 -13.4 μm Spectral Instruments CCD for regular imaging. This combination yields a FOV of $\sim 6.3 \times 6.3$ arcmin with an approximate image scale of 0.185 arcsec/pix. All images were obtained using an off-axis guide star for stability (although the field drifted a little during the observing sessions due to telescope sag), were obtained unfiltered, and were also binned 2×2 for efficiency. Exposure times also varied for each asteroid between 20s and 480s, depending on the target brightness.

Five observing nights were also recorded at the Carl Sagan Observatory belonging to the Universidad de Sonora (UNISON) in Hermosillo. This observatory operates a Meade LX-200GPS 0.41-m $f/10$ telescope equipped with a $3056 \times 3056 \times 12$ μm Apogee Alta F9000 CCD for imaging. The image frame was trimmed to a subframe of 2000×2000 pixels and then binned 2×2 yielding an effective $\sim 20 \times 20$ arcmin FOV with an image scale of about 1.2 arcsec/pix. The images at this site were obtained unguided and unfiltered. Exposure times varied between 70 s and 240 s.

Images from these observatories were processed in the standard manner using nightly dark current and flat-field files. Photometric measurements and lightcurve analysis were performed using *MPO Canopus* (version 10.7.3.0). Although all observations were unfiltered, differential magnitudes were calculated based on R-band stellar magnitudes.

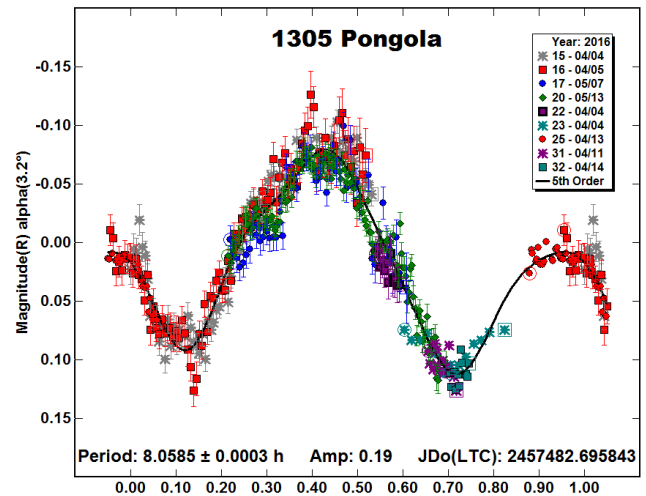
703 Noëmi was discovered by Johann Palisa on 1910 October 3 and named for Baroness Valentine Noëmi von Rothschild (Schmadel, 2003). This S-class asteroid from the Flora Family was observed on five nights from the OAN-SPM Observatory (2016 Oct 13, 16, 20 & Nov 10, 11), four nights from the UDEM Observatory (2016 Nov 1, 28 & Dec 1, 7) and two nights at the UNISON Observatory (2016 Oct 30 & Nov 2). The 2016 Oct 16 observations were treated as three separate sessions because of

differences in exposure times. The 2016 Oct 30 observations were treated as two separate sessions because the FOV was slightly rotated partway through the night. Initial results showed that the asteroid brightness varied a small amount during each night, suggesting either a long rotation period and/or low amplitude. We derived a tentative long rotation period of 115.108 ± 0.014 h by matching the observations from 2016 Nov 2 and Dec 1 in the phased lightcurve, because they exhibited almost identical behavior, and then looking for other possible matches using whole fractions of that time-span and assuming a simple two-maxima and two minima lightcurve. The fact that differential photometry was performed on the unfiltered images, which meant that we could also shift the nightly observations in the brightness axis, added too many degrees of freedom in the search of a solution. Thus, we can only state that the rotation period for this asteroid is long, in the realm of tens of hours, and that our derived tentative value is only one possible solution. Our sparse observations are insufficient to cover an entire lightcurve. No other reports of the rotation period were found in the literature for this asteroid. However, A. Noschese reports on the Collaborative Asteroid Lightcurve Link website (CALL; minorplanet.info/call.html) a larger set of observations from his group that indicates a longer period of $\sim 201.9 \pm 0.8$ h, also with larger amplitude. Most of our observations predate his earliest observing date and there is little overlap, so this would be a good opportunity to join both data sets in an effort to obtain a more reliable solution to the rotation period of 703 Noëmi.

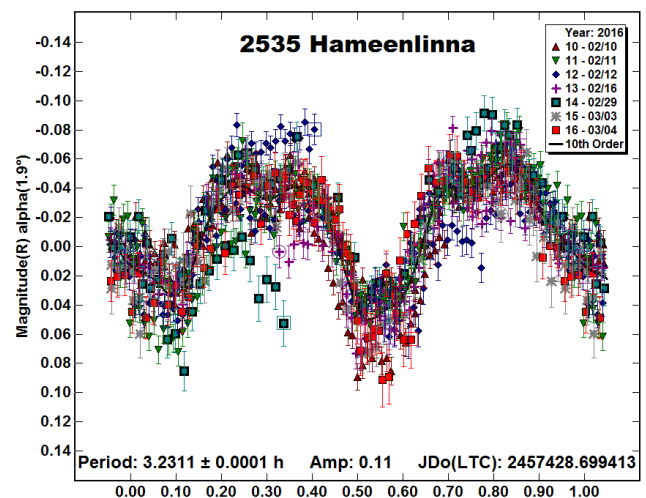


1305 Pongola. Was discovered on 1928 July 19 by H. E. Wood at Johannesburg and named for a river in South Africa (Schmadel, 2003). This C-class outer main-belt asteroid was observed at the UdeM Observatory on three nights (2016 Apr 4, 5 & May 7) and at OAN-SPM Observatory on five (2016 April 4, 11, 13, 14 & May 13). During analysis, the 2016 April 4 observations were treated as three separate sessions because of differences in exposure times of the image sets and because they were obtained at two separate observatories. The April 11, 13, and 14 observing sessions were short, obtained during time gaps of other assigned projects, but still provided useful data to complement the lightcurve. A total of 457 data points was used to find a period of 8.0585 ± 0.0003 h with an amplitude of ~ 0.19 mag. Initial rotation period determinations were made by Binzel (1987; 8.03 ± 0.10 h) and Ditteon et al. (2012; 8.06 ± 0.02 h). More recently, Waszczak et al. (2015) reported a rotation period of 8.0586 ± 0.0015 h with an amplitude of 0.17 mag, while Mansego et al. (2016) reported a period of 8.335 ± 0.002 h with an amplitude of 0.16 mag. Our

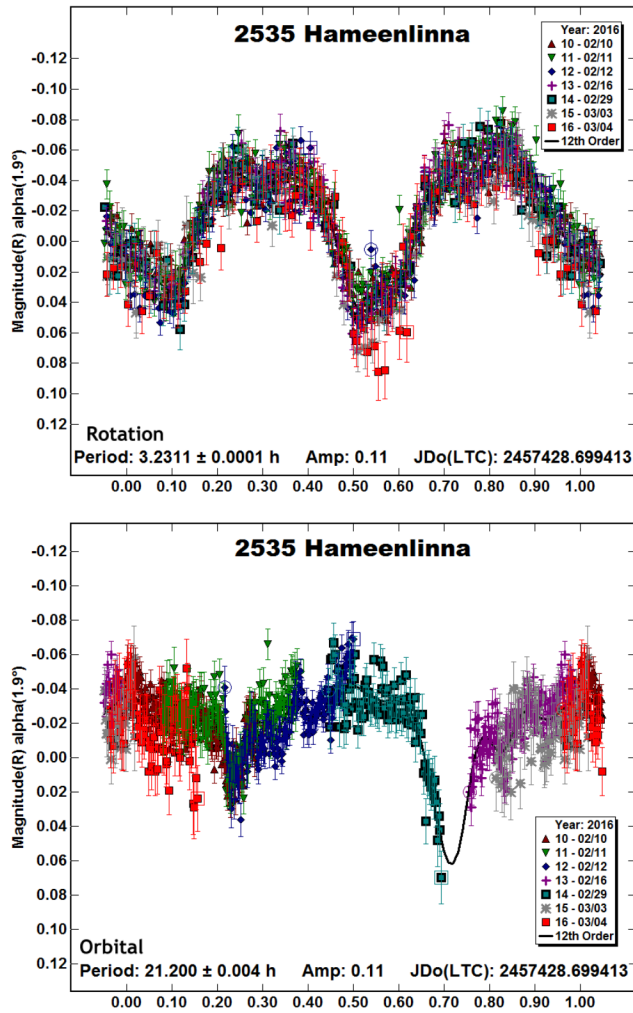
resulting period and amplitude are in better agreement with those obtained by Waszczak et al. (2015).



2535 Hämeenlinna was discovered in 1939 February 17 by Y. Väisälä at Turku and named for an old town in the province of Häme (Schmadel, 2003). This S-class asteroid from the Flora family was observed at the UdeM Observatory on eight nights (2016 Feb 10, 11, 12, 16, 29 & Mar 3, 4, 13). On two of these nights (2016 Feb 11 and Mar 3), the asteroid was also observed from the UNISON Observatory, extending the nightly observing period because of its location further west. For the final analysis, the night of 2016 Mar 13 was not included since it was much noisier than the rest. From the onset, this asteroid exhibited a clear ~ 3.23 h period. However, each night the asteroid also exhibited a different overall trend in the data with each successive period not quite matching the previous ones. This was particularly evident in the two extended observing sessions from both observatories. The asteroid was thus suspected as having two periods and further observations were programmed until it was too faint to follow. The following figure below shows the best-fit single period obtained for the data. It confirms a 3.2311 ± 0.0001 h rotation period, but also exhibits larger than usual scatter.



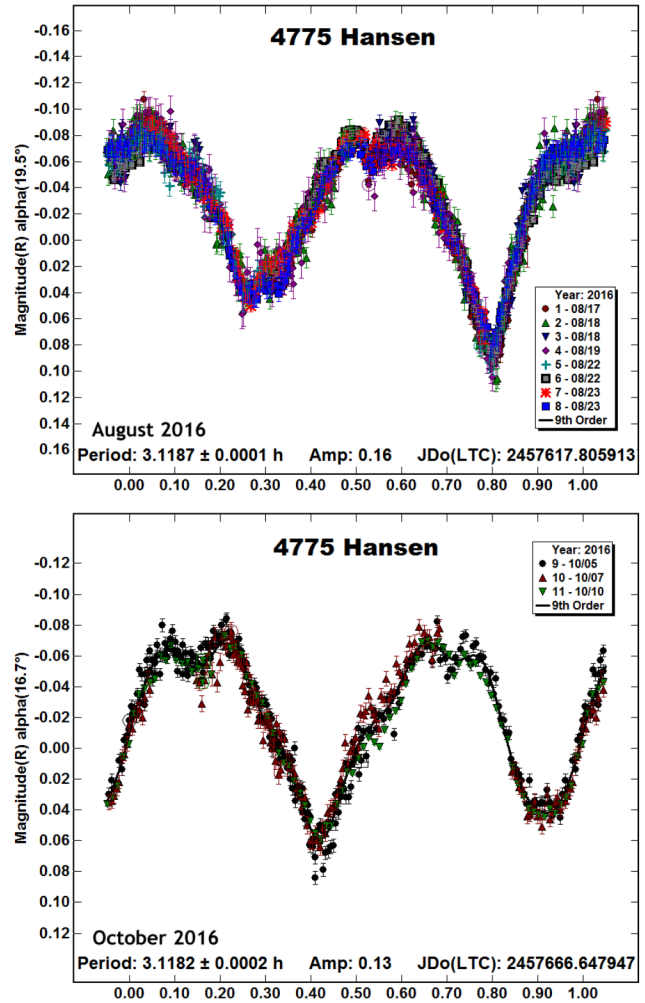
It was decided to use the dual period option included in *MPO Canopus* to attempt to disentangle the possibility of two periods. The results are shown in the next two figures.



Our initial short rotation period of 3.2311 ± 0.0001 h with an amplitude of 0.11 mag was maintained and the scatter was considerably reduced. An additional period of 21.20 ± 0.004 h with an amplitude of 0.11 mag is also extracted from the data. This second lightcurve exhibits what appear to be primary and secondary attenuations due to the possible presence of a small companion orbiting the asteroid. The secondary attenuation was well sampled by our data, but not the primary. This renders the derived possible orbital period of the companion as tentative since other nearby periods could also fit the data, which has an overall scatter similar to the derived amplitude. The only other report about 2535 Hämeenlinna found in the literature is from Benishek et al. (2016) in which they report that this asteroid is a binary system where the primary exhibits a rotation period of 3.23106 ± 0.00006 h, the secondary shows a synchronous orbital period of 21.23 ± 0.01 h, and the reported lightcurve amplitude is 0.10 mag.

They also register eclipse/occultation events with depths of 0.05–0.10 mag. Our data independently confirms this preliminary report from Benishek et al. (2016).

4775 Hansen was discovered in 1927 Oct 3 by Maximilian Franz Wolf at Heidelberg and named after the German astronomer Peter Andreas Hansen (Schmadel, 2003). This is a C-class asteroid that crosses the orbit of Mars. It was observed on six nights at the OAN-SPM Observatory (2016 Aug 17, 18, 19, 22, 23 & Oct 10) and two nights at the UDEM Observatory (2016 Oct 5, 7). During analysis, the 2016 Aug 22 and 23 observations were treated as two separate sessions.



Using the combined data set, we derived a period of 3.1186 ± 0.0001 h with an amplitude of 0.15 mag. This is in general agreement with the results of $P = 3.1185 \pm 0.0001$ h and amplitude of 0.18 mag obtained by Pravec et al. (2016), but in slight disagreement with the results of $P = 3.124 \pm 0.001$ h and

Number	Name	2016 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
703	Noemi	10/13–12/07	1104	18.4, 15.0	50	–1	*115.108	0.014	0.28	0.05	FLO
1305	Pongola	04/04–05/13	457	3.2, 12.4	202	2	8.0585	0.0003	0.19	0.02	MBO
2535	Hämeenlinna	02/10–03/04	940	1.9, 12.3	143	–2	2.2311	0.0001	0.11	0.02	FLO
4775	Hansen	08/17–08/23	1511	19.5, 16.4	342	–1	3.1187	0.0001	0.16	0.02	MC
4775	Hansen	10/05–10/10	507	16.7, 18.8	5	12	3.1182	0.0002	0.13	0.02	MC

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

* The rotation period of 703 Noemi is not secured and additional observations are needed to derive its real value.

amplitude of 0.12 mag obtained by Warner (2017). We note that the lightcurve did show some variation in shape and amplitude between the observations performed the third week of August vs. those performed the first week of October. The October data exhibits a noticeable decrease in amplitude, from 0.16 mag to 0.13 mag, suggesting a more pole-on view, as outlined by Warner (2017) from his 2016 November observations.

Acknowledgements

The results presented in this report were partially based on observations acquired at the Observatorio Astronómico Nacional on the Sierra de San Pedro Mártir, Baja California, México. Laura Cantú-Sánchez is working on her Master's Degree at the Planetary Astrophysics Program of the Universidad Autónoma de Nuevo León.

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ASTEROID 4296 VAN WOERKOM: A NEWLY DISCOVERED ASYNCHRONOUS BINARY

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We report that asteroid 4296 van Woerkom is a binary asteroid. Lightcurve analysis for images taken from 2016 November through December reveals a primary rotational period of 2.80868 ± 0.00005 h and a secondary orbital period of 26.22 ± 0.01 h.

Photometric observations of asteroid 4296 van Woerkom were initiated as a part of an astronomy research class taught at Phillips Academy, a high school in Andover, Massachusetts. Students used the CALL website (<http://minorplanet.info/call.html>) to identify asteroids with previously unmeasured periods and favored candidates with high declinations, apparent visual magnitudes between 15 and 17, and appealing names.

The first night of imaging 4296 van Woerkom revealed a short rotation period. Attenuations were noted on Dec 3 and 9. Suspecting a binary asteroid, Odden contacted Brian Warner, who agreed that the asteroid was likely a binary (*private communications*). Pilcher, Klinglesmith, and Benishek joined the observing campaign, and Petr Pravec kindly offered to use his method to analyze the combined observations of 4296 van Woerkom.

Once the approximate orbital period was established, observation windows were selected to correspond with eclipse events. Table 1 lists the equipment used by the various observers.

Observer	Telescope (m)	CCD Camera
Pilcher	0.35 f/10 SCT	STL-1001E
Benishek	0.35 f/6.3 SCT	ST-8XME
Klinglesmith	0.35 f/11 SCT	STL-1001E, ST-10
Odden	0.40 f/8 R-C	Andor Tech iKon DW 436 C

Table 1. Observers and equipment. SCT: Schmidt-Cassegrain Telescope; R-C: Ritchey-Chrétien