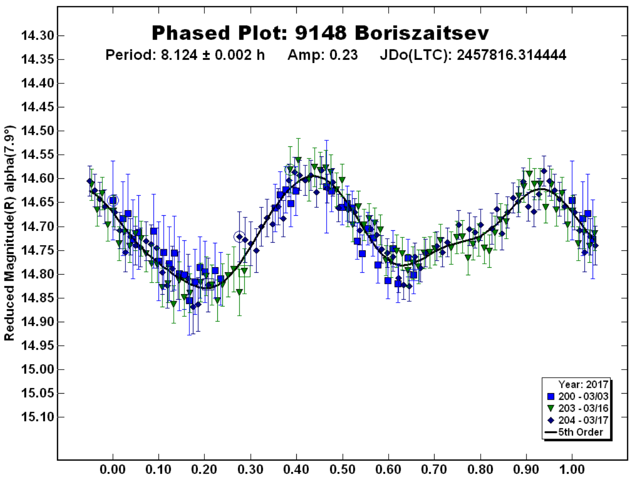

According to JPL, the absolute magnitude is H = 14.2 with a diameter of 3.743 ± 0.012 km, which leads to an optical albedo of 0.190 ± 0.022 (JPL, 2017). The WISE survey (Masiero et al., 2011) used H = 14.3 to find D = 3.699 ± 0.073 km. From this, an optical albedo of p_V = 0.247 ± 0.042 was derived.

Observations of this asteroid were conducted on three nights, collecting a total of 182 data points. The period analysis shows a clear bimodal solution with P = 8.124 ± 0.002 h and amplitude A = 0.23 ± 0.02 mag.

Acknowledgements

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DENSITY AND AXIS-SIZE RELATIONSHIP OF FIVE MAIN-BELT ASTEROIDS: 2017 JANUARY – MARCH

Amadeo Aznar Macías
APT Observatories Group, SPAIN
aptog@aptog.com

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Despite many decades of minor planet studies focused on external and dynamical properties, there are still hundreds of asteroids that have never been measured. Presented here are the results of photometric analysis applied to five main-belt asteroids. In addition to calculating rotation period, axis ratios assuming a simple ellipsoidal shape and the estimated minimum density of each asteroid are reported.

During the first trimester of 2017, the APT Observatories Group (APTOG onwards) continued with its regular analysis of main-belt asteroids using photometric techniques. During recent years, the group has analyzed more than one hundred main-belt asteroids as well as more than one hundred near-Earth asteroids (NEAs). We have discovered five binary asteroids (see IAU CBET 4272, 4316, 4326, 4345, and 4361). All this work constitutes the APT Asteroid Photometric Survey, which collects lightcurves obtained from APTOG and other observatories, including some within the EURONEAR network.

The APT Observatory Group is made up of two observatories. First is the Isaac Aznar Observatory located in Aras de los Olmos town, Valencia, Spain, under dark skies (~21.7 mag/arcsec^2). The image scale is 1.44 arcsec/pixel. The second observatory, POP-Punto de Observación de Puçol, Puçol, Spain, is in a semi-urban location equipped with a 0.25-m telescope, SBIG ST-9 CCD, and adaptive optics. The image scale is 1.56 arcsec/pixel.

All images were obtained in 1x1 binning mode and were taken using a clear filter, except for 1106 Cydonia, which was observed using Johnson V and Sloan r´ (SR) filters. The SNR for the target assured a lightcurve of sufficient quality and low data dispersion. Dark and bias frames and twilight sky flat-fields were applied to each image.

Table I shows the observation circumstances and period analysis results; Table II shows the derived ellipsoid ratios and densities.

Analysis

Data reduction was done with *MPO Canopus*. This software implements the FALC period analysis algorithm developed by Harris (Harris *et al.,* 1989). The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. The comp star magnitudes were taken from the CMC15 and MPOSC3 catalogs, depending on availability of comparison stars. The APASS catalog was used for 1106 Cydonia SR magnitudes. The nightly zero points for both catalogs have been found to be generally consistent to about ± 0.05 mag or better.

The StarBGone star subtraction algorithm in *MPO Canopus* was used when needed in order to remove the effect of stars located in the asteroid's path. This is most effective when the star's SNR is equal to or lower than asteroid's SNR. (Aznar, 2013).

When doing period analysis, the period spectrum (RMS vs. period) was reviewed to check for the possibility of other plausible solutions. The number of orders used in the Fourier analysis was dependent on the quality of the lightcurve data (in number and dispersion). A conservative approach was adopted to ensure that using too high of harmonic order did not adversely affect the end result. This becomes important when estimating the shape of the body based on the lightcurve amplitude. For example, a lightcurve with a large amplitude implies an highly elongated shape. If too high a Fourier order is used, the resulting model lightcurve may have an amplitude that is much larger than the shape would actually produce.

Assuming a triaxial body model where a > b > c (Jacobi ellipsoid) and the object rotates about the c-axis (Harris and Lupishko 1989) it is possible to determine a/b axis ratio from the lightcurve amplitude assuming the body has sufficient gravity and low enough rigidity to pull itself into an equilibrium shape. This assumption is likely violated for objects in the size range we discuss here, where the rigid strength of the body (or its constituents if fractured) are likely to dominate the final shape compared to gravitational relaxation into an equilibrium figure. Nevertheless, we proceed with our analysis as an exercise in computing minimal densities for these objects under the equilibrium figure assumption.

When trying to estimate shape information, it is necessary to calibrate the amplitude value A(α) to the amplitude at zero phase angle A(0) (Zappala et al., 1990) before trying to estimate the axis ratio. Taking into account the amplitude lightcurve calibrated to zero phase angle, the axis ratios were found for the five asteroids reported here.

It must be said that since the spin axis orientation of the target is unknown, only a lower limit for axis-size relationship can be found. For the values reported here, it was assumed that the observations were made with the center of the optical disc at or near the asteroid equator, i.e., an "equatorial view," and the asteroid is rotating about the c axis (Binzel et al., 1989).

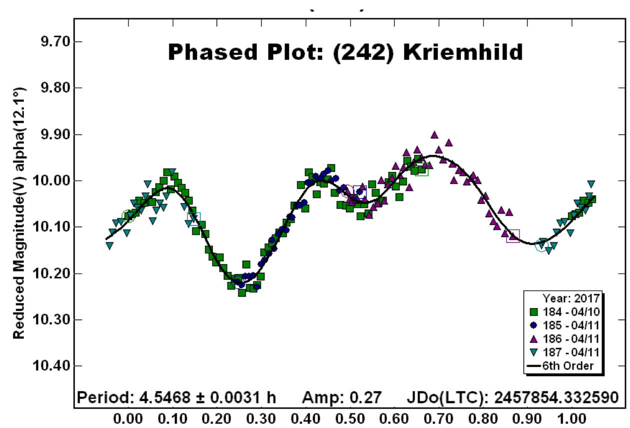
Although density calculations are a subtle task, an attempt was made to calculate the minimum density for each asteroid. The lower limit calculated density for these asteroids was derived by using a criterion for the critical limit of rotation period that depends only on the density of the asteroid.

A rotating sphere will be in a state of hydrostatic equilibrium as long as the rotation frequency does not exceed the surface orbit frequency about the sphere. That assumption means that the centrifugal acceleration at the equator is less than the acceleration of gravity (Pravec and Harris, 2000). Comparing the acceleration of gravity at the surface with the centrifugal acceleration at the equator, it is possible to derive a criterion for the critical limit of rotation period ($P_C = 2\pi/\omega_c$), which depends on the density (*ρ*) of the sphere,

$$Gm/r^2 = \omega^2_c\, r \rightarrow Pc = 3.3\ h\ \sqrt{\rho}$$

where *G* is the gravitational constant, *m* is the mass of the sphere, and *r* is its radius; ρ is expressed in g/cm^{-3}. There were no previous density estimates against which to compare the results. Since the taxonomic type was not known, it was not possible to compare the results to average values assumed for various taxonomic classes. Regarding the density data interpretation, $\rho < 1\ gcm^{-3}$ reveals a porous internal structure while $\rho > 1\ gcm^{-3}$ suggests a rocky internal structure (Thirouin et al, 2010).

242 Kriemhild. There are eight entries in lightcurve database (LCDB; Warner et al., 2009) that give a period, all of them being about 4.53 h. Analysis of the observations made in 2017 April found *P* = 4.5468 ± 0.0031 h, which is similar to the LCDB entries.

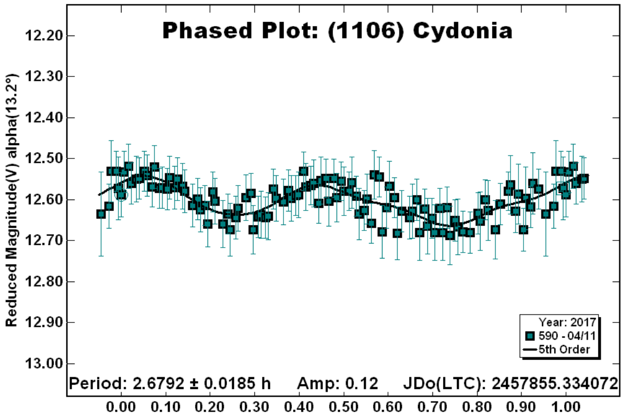


1106 Cydonia. This is a 12.41 km S-type asteroid. Only one night was required to find the rotation period of *P* = 2.6792 ± 0.12 h, which matches Klinglesmith et al. (2016). The lightcurve shows a typical bimodal shape with an amplitude of 0.12 mag, suggesting a nearly spherical shape, or a nearly pole-on viewing aspect.

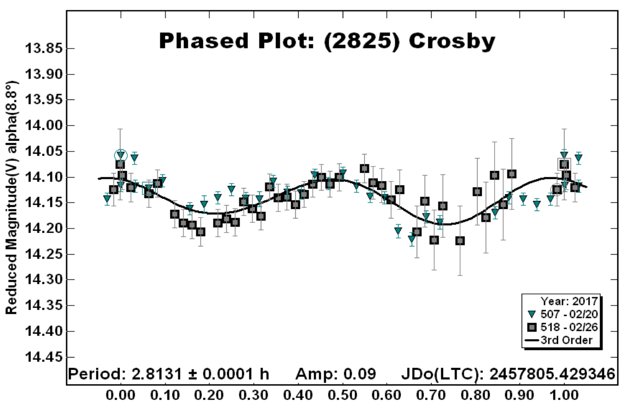
Observations were made Johnson V and Sloan r´ filters in order to calculate the color index. The analysis shows that this main-belt asteroid has a color index V-r´ = 0.152.

[redacted]

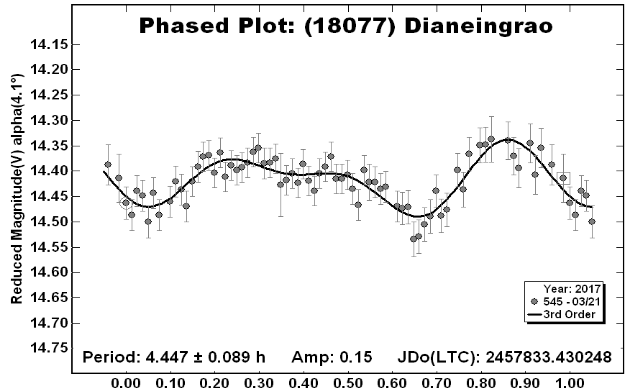
[redacted]



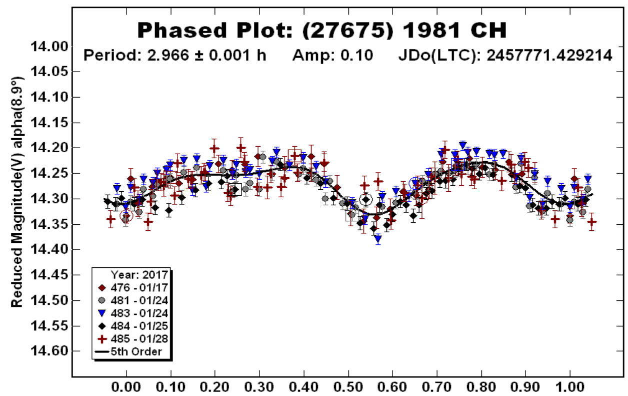
2825 Crosby. This is a binary main-belt asteroid. The satellite was discovered in 2017 February by Pray et al. (2017a). We observed the asteroid for a total of seven hours and our analysis found a period of 2.8131 ± 0.0179 h. This matches the primary period found by Pray et al. (2017a) who assumed a density of 1.6 gcm^{-3}. This is similar to ρ = 1.6 gcm^{-3} given here. Again, this value is a minimum since it assumed a full equatorial view of the asteroid when finding the axis ratios.



18077 Dianeingrao. No references with period were found in LCDB for this target. APTOG followed this asteroid for one night. Inclement weather prevented additional observations. The lightcurve has a period of P = 4.447 ± 0.089 h, but this is not certain. Observations at future oppositions are encouraged.



(27675) 1981 CH. This is a binary main-belt asteroid. The satellite was discovered in 2017 February by Pray et al. (2017b). Members of the APTOG group were among the co-discoverers. The rotation period obtained by APTOG of P = 2.966 ± 0.001 h matches the period from Pray et al. (2017b).



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LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2017 JULY-SEPTEMBER

Brian D. Warner
Center for Solar System Studies / MoreData!
446 Sycamore Ave.
Eaton, CO 80615 USA
brian@MinorPlanetObserver.com

Alan W. Harris
MoreData!
La Cañada, CA 91011-3364 USA

Josef Ďurech
Astronomical Institute
Charles University in Prague
18000 Prague, CZECH REPUBLIC
durech@sirrah.troja.mff.cuni.cz

Lance A.M. Benner
Jet Propulsion Laboratory
Pasadena, CA 91109-8099 USA
lance.benner@jpl.nasa.gov

We present lists of asteroid photometry opportunities for objects reaching a favorable apparition and have no or poorly-defined lightcurve parameters. Additional data on these objects will help with shape and spin axis modeling via lightcurve inversion. We also include lists of objects that will be the target of radar observations. Lightcurves for these objects can help constrain pole solutions and/or remove rotation period ambiguities that might not come from using radar data alone.

We present several lists of asteroids that are prime targets for photometry during the period 2017 July-September.

In the first three sets of tables, "Dec" is the declination and "U" is the quality code of the lightcurve. See the asteroid lightcurve data base (LCDB; Warner *et al.*, 2009) documentation for an explanation of the U code:

http://www.minorplanet.info/lightcurvedatabase.html

The ephemeris generator on the CALL web site allows you to create custom lists for objects reaching V ≤ 18.5 during any month in the current year, *e.g.*, limiting the results by magnitude and declination.

http://www.minorplanet.info/PHP/call_OppLCDBQuery.php

We refer you to past articles, e.g., *Minor Planet Bulletin* **36**, 188, for more detailed discussions about the individual lists and points of advice regarding observations for objects in each list.

Once you've obtained and analyzed your data, it's important to publish your results. Papers appearing in the *Minor Planet Bulletin* are indexed in the Astrophysical Data System (ADS) and so can be referenced by others in subsequent papers. It's also important to make the data available at least on a personal website or upon request. We urge you to consider submitting your raw data to the ALCDEF page on the Minor Planet Center web site:

http://www.minorplanetcenter.net/light_curve