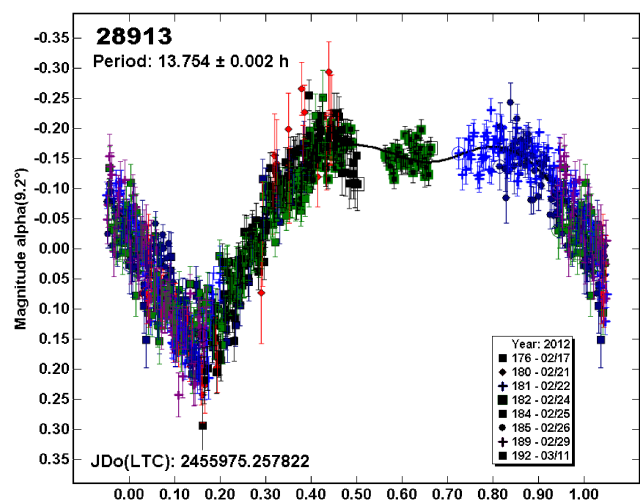
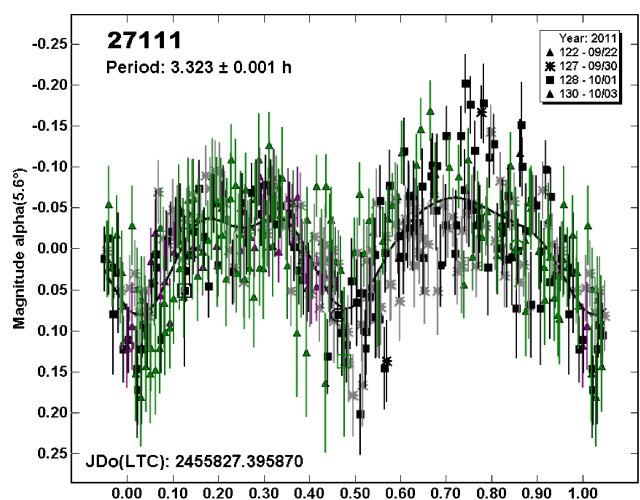
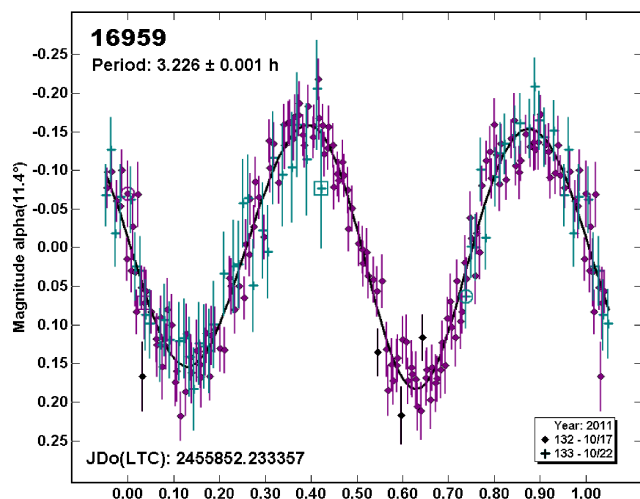




CCD PHOTOMETRY AND LIGHTCURVE ANALYSIS OF MAIN-BELT ASTEROIDS 14 IRENE, 4874 BURKE, 1985 HOPMANN, 3017 PETROVIC, AND 3070 AITKEN FROM OBSERVATORI CARMELITA IN TIANA

Josep Maria Aymami

Observatori Carmelita (MPC B20)

Av. P. Lluís Companys, 45, 08391 Tiana, Spain

josepmaria.aymami@gmail.com

(Received: April 8)

Observations carried out from 2011 December to late 2012 March allowed us to determine the synodic periods of 14 Irene, 1985 Hopmann, 3017 Petrovic, 3040 Aitken, and 4874 Burke. For 14 Irene, a period of 15.038 ± 0.002 h was found with an amplitude $A = 0.10$ mag, well in accordance with other published estimates. 1985 Hopmann exhibited a rotational period of 17.476 ± 0.003 h, $A = 0.44$ mag. 3017 Petrovic exhibited a rotational period of 4.080 ± 0.001 h, $A = 0.62$ mag. 3070 Aitken showed a period of 6.390 ± 0.005 h, $A = 0.59$ mag. For 4874 Burke we found a short rotational period of 3.657 ± 0.001 h with $A = 0.31$ mag.

The Carmelita Observatory (MPC B20) is situated in Tiana, in the southernmost part of the Serra de Marina, a moderately light-polluted suburban park 15 km north of Barcelona, Spain. The observatory is equipped with an Astro-Physics AP900 German equatorial mount on top of a fixed pier, a 25-cm Schmidt-Cassegrain telescope with a focal reducer, and a dual-chip SBIG ST8-XME CCD camera with filter wheel. However, for this particular imaging run, a 13-cm triplet refractor with a field flattener yielding an effective resolution of 2.08 arcsec/pix was used.

14 Irene (1952 TM) is a main-belt asteroid ($e = 0.16569$, $a = 2.5874$) of very respectable size (about 150 km) that was discovered by J. R. Hind in 1851. It is known that the asteroid lightcurve is very shallow, and several rotational periods have been estimated over the years. The most recent data sets published are those from Hanus *et al.* (2011) and Pilcher (2009). They determined synodic periods of 15.02991 h and 15.028 h, respectively. The 2011-2012 apparition presented an excellent opportunity for the small refractor, with the asteroid at $V \sim 10.8$. We collected more than 3,000 60-s images from 2011 December 18 to 2012 January 10 through a C filter with Maxim DL acquisition software. The CCD camera operated at -15° C and all images were calibrated with master bias, dark, and flat frames. We performed real-time differential photometry of the asteroid with *Fotodif* as the images were being downloaded. With *MPO Canopus* we derived a lightcurve showing a period of 15.038 ± 0.002 h and amplitude $A = 0.10$ mag. This agrees well with the most recent results.

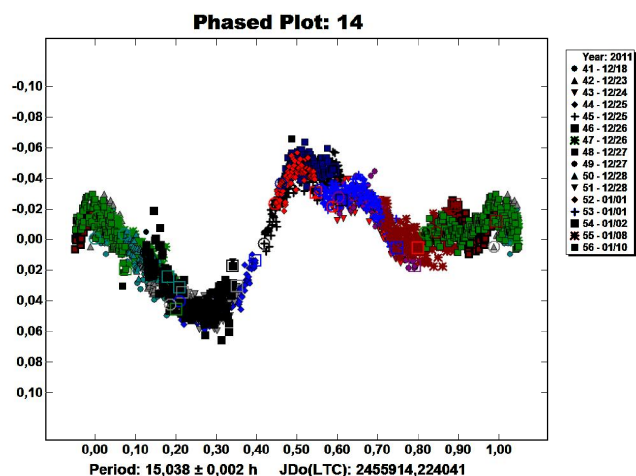


Figure 1. Lightcurve for 14 Irene.

1985 Hopmann (1929 AE) is a main-belt asteroid ($e = 0.15267$, $a = 3.1223$) that was also listed as being in need of photometric measurements the Lightcurve Photometry Opportunities list by Warner *et al.* (2011). This asteroid was discovered by K. Reinmuth Heidelberg in 1929. We could find no previously-published rotational data. We obtained 1320 150-s images of the asteroid through a clear filter on 15 nights in 2012 February with the CCD operating at -15° C. The asteroid brightness reached 14.3-14.4 as estimated by *Astrometrica*. Analysis of the data allowed us to determine a synodic period of 17.476 ± 0.003 h, $A = 0.44$ mag. Figure 2 shows the composite lightcurve.

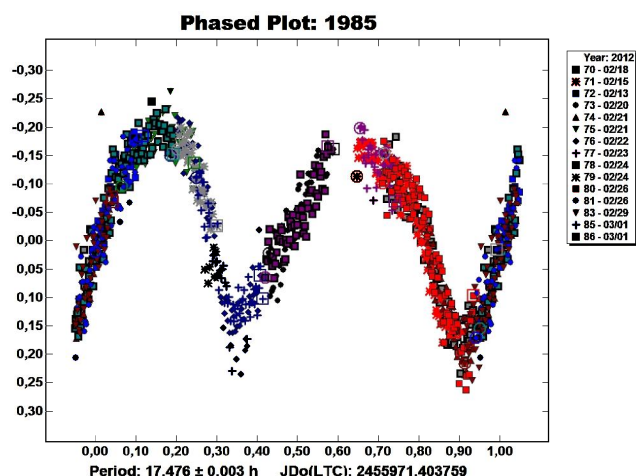


Figure 2. Composite lightcurve for 1985 Hopmann.

3017 Petrovic was another main-belt asteroid listed as an asteroid in the Lightcurve Opportunity list by Warner *et al.* (2011). Angeli and Barucci (1996) estimated a period of 4.069 h, although their observations lacked full coverage. We observed this asteroid on several nights, but it was only possible to reduce data of four of them due to the asteroid moving through the dense star fields of Canis Minor. 350 150-s images through a clear filter were obtained in unbinned mode and the CCD camera working at -15°C . According to our measurements with *Astrometrica* against CMC-14 stars in R-band, the asteroid brightness was 14.2-14.5 mag. We derived a lightcurve that shows a fast rotational period of 4.080 ± 0.001 h and an amplitude of 0.62 mag. Figure 3 shows the composite lightcurve.

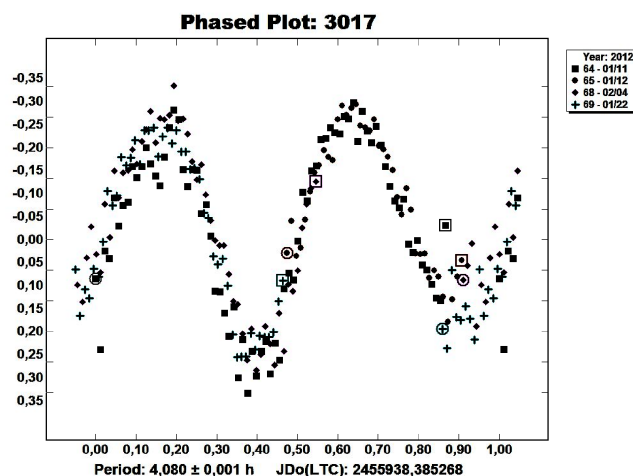


Figure 3. Composite lightcurve for 3017 Petrovic.

3070 Aitken (1949 GK) is one of the many main-belt asteroids ($e = 0.19825$, $a = 2.3056$) discovered in 1949 from the Goethe Link Observatory during the Indiana Asteroid Program. It was also mentioned in the Lightcurve Photometry Opportunities list by Warner *et al.* (2012) as most others appearing in this article. We followed the asteroid at the end of 2012 March when its brightness was $R = 14.7\text{--}15.2$, according to the CMC-14 star catalogue. 460 images of 150 s were obtained with the CCD working at -12°C and were calibrated with dark, flat and bias frames. Our analysis with *MPO Canopus* suggests a rotational period of 6.390 ± 0.005 h and $A = 0.59$ mag.

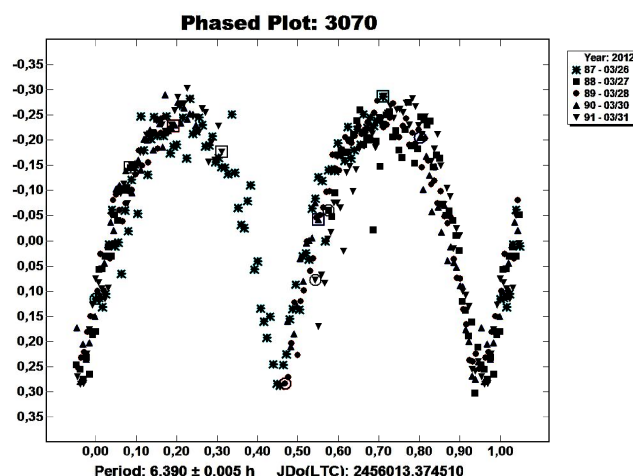


Figure 4. Composite lightcurve for 3070 Aitken.

4874 Burke (1991 AW, $e = 0.12250$, $a = 2.6022$) is a main-belt asteroid discovered by Eleanor Helin at Palomar Observatory in 1991. No published data were available for this asteroid, which had been included in the Lightcurve Photometry Opportunities list by Warner *et al.* (2011). 753 calibrated images of 150 s through a clear filter were collected with *Maxim DL* during nine nights from 2011 December 28 to 2012 January 22 with the CCD working at -15°C . The asteroid brightness was measured against the CMC-14 catalogue in R band at mag 15.0-15.3. Real-time images processed with *Fotodif* soon revealed a fast rotating body. Figure 5 shows part of the lightcurve of December 31.

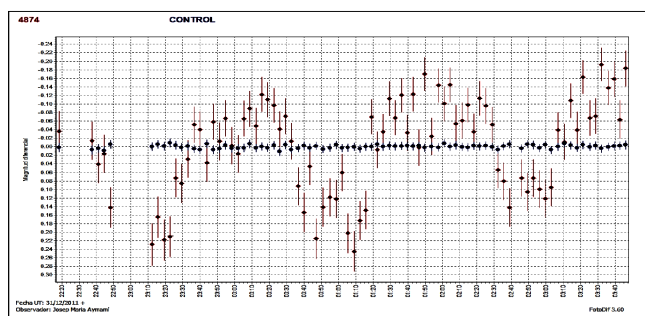


Figure 5. Lightcurve for 4874 Burke on 2011 December 31.

The lightcurves obtained were relatively noisy due to the modest telescope aperture, even though the lower resolution provided by the refractor allowed us to carry out longer exposures than would have been possible with the 25-cm reflector. With *MPO Canopus* we produced a lightcurve of two maxima showing a synodic period of 3.657 ± 0.001 h and $A = 0.31$ mag. Figure 6 shows the composite lightcurve.

Acknowledgements

Special thanks are due to Ramón Bosque, a member of the Grup d'Astronomia de Tiana (G.A.T.) for revising this paper, and to Julio Castellano for constantly improving *Fotodif* with new features. The Grup d'Astronomia de Tiana (G.A.T.) granted access to *MPO Canopus* so that we could derive the lightcurves appearing in this paper.

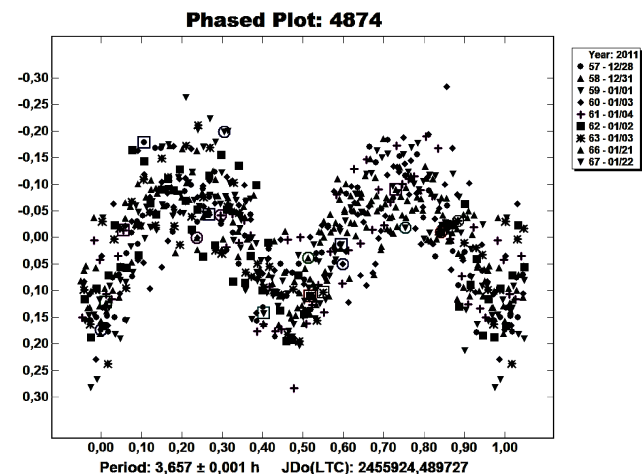


Figure 6. Composite lightcurve for 4874 Burke.

References

- Angeli, C.A. and Barucci, M.A. (1996). "CCD Observations: rotational properties of 13 small asteroids." *Planetary and Space Science* **44**, 181-186.
- Carlsberg Meridian Catalogue-14 (CMC-14)
<http://www.ast.cam.ac.uk/~dwe/SRF/cmc14.html>
- Castellano, J. *Fotodif* software. Focas II, Orbitas,
<http://astrosurf.com/orodeno/fotodif/index.htm>
- Hanuš, J., Ďurech, J., Brož, M., Warner, B. D., Pilcher, F., Stephens, R., Oey, J., Bernasconi, L., Casulli, S., Behrend, R., Polishook, D., Henych, T., Lehký, M., Yoshida, F., and Ito, T. (2011). "A study of asteroid pole-latitude distribution based on an

extended set of shape models derived by the lightcurve inversion method." *Astron. Astrophys.* **530**, A134.

JPL HORIZONS Ephemeris System:
<http://ssd.jpl.nasa.gov/?ephemerides>

Pilcher, F. (2009). "New lightcurves of 8 Flora, 13 Egeria, 14 Irene, 25 Phocaea, 40 Harmonia, 74 Galatea, and 122 Gerda." *Minor Planet Bulletin* **36**, 133-136.

Raab, H. *Astrometrica* software. <http://www.astrometrica.at/>

Warner, B.D. (2008). MPO Software, *MPO Canopus* version 9.5.0.3. Bdw Publishing, Colorado Springs, CO.

Warner, B.D., Harris A.W., Pravec, P., Ďurech J., and Benner L.A.M. (2011). "Lightcurve Photometry Opportunities: 2011 October-December." *Minor Planet Bulletin* **38**, 224-229.

Warner, B.D., Harris A.W., Pravec, P., Ďurech J., and Benner L.A.M. (2011). "Lightcurve Photometry Opportunities: 2012 January-March." *Minor Planet Bulletin* **39**, 31-34.

Warner, B.D., Harris A.W., Pravec, P., Ďurech J., and Benner L.A.M. (2011). "Lightcurve Photometry Opportunities: 2012 April-June." *Minor Planet Bulletin* **39**, 94-97.

ASTEROIDS OBSERVED FROM GMARS AND SANTANA OBSERVATORIES: 2012 JANUARY - MARCH

Robert D. Stephens
 Center for Solar System Studies / MoreData! Inc.
 11355 Mount Johnson Court, Rancho Cucamonga, CA 91737
RStephens@foxandstephens.com

(Received: 11 April)

Lightcurves of five asteroids were obtained from Santana Observatory and Goat Mountain Astronomical Research Station (GMARS): 369 Aeria, 1985 Hopmann, 4106 Nada, 2842 Unsold, and (35886) 1999 JG80.

With the exception of (35886) 1999 JG80, all observations were made at Santana Observatory (MPC Code 646) using a 0.30-m Schmidt-Cassegrain (SCT) with a SBIG STL-1001E CCD camera. All images were unguided and unbinned with no filter. (35886) 1999 JG80 was observed at GMARS (MPC Code G79) using a 0.35-m Schmidt-Cassegrain (SCT) with a SBIG STL-1001E. Measurements were made using *MPO Canopus*, which employs differential aperture photometry to produce the raw data. Period analysis was done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). Except for (35886) 1999 JG80, the asteroids were selected from the list of asteroid photometry opportunities published on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner, 2012).

The results are summarized in Table I. Night-to-night calibration of the data (generally $< \pm 0.05$ mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner, 2007; Stephens, 2008).