SEVEN NEAR-EARTH-ASTEROIDS AT ASTEROIDS OBSERVERS (OBAS) – MPPD: 2016 JUNE–NOVEMBER

Juan Lozano
Elche Observatory, Alicante, SPAIN
obas@minorplanet.es

Angel Flores, Vicente Mas, Gonzalo Fornas CAAT, Centro Astronómico del Alto Turia, SPAIN

Onofre Rodrigo
Bétera Observatory, Valencia, SPAIN

Pedro Brines
TRZ Observatory, Valencia, SPAIN

Alvaro Fornas
Oropesa Observatory, Castellón, SPAIN

David Herrero
Serra Observatory, Valencia, SPAIN

Alfonso Carreño
Zonalunar Observatory,Valencia, SPAIN

Enrique Arce
Vallbona Observatory, Valencia, SPAIN

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We report on the results of photometric analysis on seven near-Earth asteroids (NEA) by Asteroides Observers (OBAS). This work is part of the Minor Planet Photometric Database effort that was initiated by a group of Spanish amateur astronomers. We have managed to obtain a number of accurate and complete lightcurves as well as some additional incomplete lightcurves to help analysis at future oppositions.

In this paper we publish the results for seven near-Earth asteroids analyzed under the Minor Planet Photometric Database project (*http://www.minorplanet.es*). The data and results were made possible thanks to the collaboration of the Astronomical Center Alto Turia (CAAT) observatory located in Aras de los Olmos and operated by members of the Valencia Astronomy Association (AVA) (*http://www.astroava.org*).

Observatory	Telescope (meters)	CCD
C.A.A.T.	0.45 DK	SBIG STL-11002
Zonalunar	0.20 NW	QHY6
Vallbona	0.25 SCT	SBIG ST7-XME
TRZ	0.20 R-C	QHY8
Elche	0.25 DK	SBIG ST8-XME
Oropesa	0.20 SCT	Atik 16I
Bétera	0.23 SCT	Atik 314L+
Serra Observatory	0.25 NW	Atik 414L+

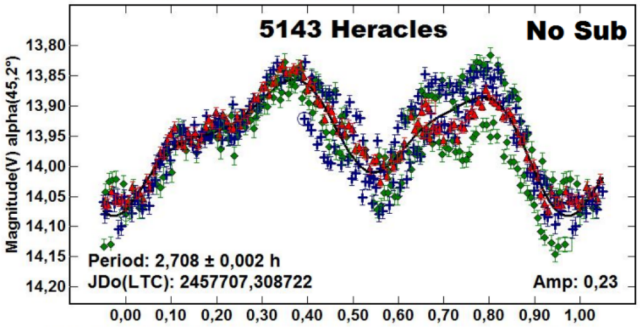
Table I. List of instruments used for the observations. SCT is Schmidt-Cassegrain. R-C is Ritchey-Chrétien. DK is Dall-Kirkham. NW is Newtonian.

Table I shows the equipment at observatories that participated in this work. We concentrated on asteroids with no reported period and those where the reported period was poorly established and needed confirmation. All the targets were selected from the Collaborative Asteroid Lightcurve (CALL) website at (*http://www.minorplanet.info/call.html)* and Minor Planet Center (*http://www.minorplanet.net*)

Images were measured using *MPO Canopus* (Bdw Publishing) with a differential photometry technique.

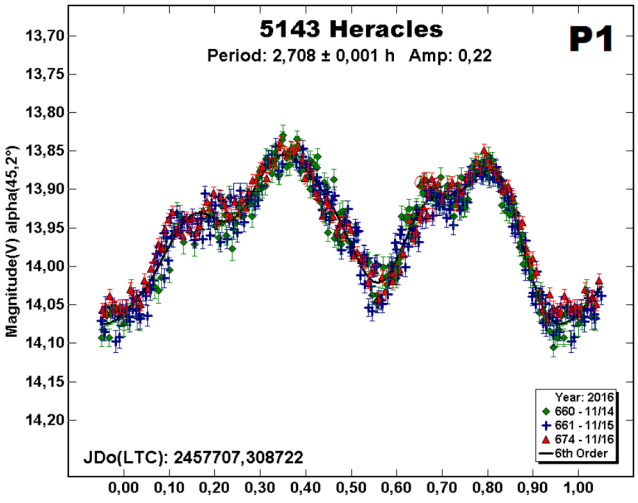
5143 Heracles. This is a main-belt asteroid discovered in 1991. A small satellite was detected with radar in 2012 (Taylor *et al.* 2012). Pilcher et al. (2012), using optical observations at about the same time, reported the object as a suspected binary with a primary period of 2.7063 h. They were not able to determine an orbital period for the suspected satellite. Our observations, made on three nights in 2016 Nov, were the result of a group effort, especially the team at CAAT. At the time of our observations, Heracles was moving at 4 arcseconds/min, which required exposures of less than 60 seconds.

The initial period analysis with *MPO Canopus* found a bimodal lightcurve with a period of 2.708 ± 0.002 h and amplitude of 0.23 mag, which was in good agreement with the period found by Pilcher et al. (2012). However, as seen in the "No Sub" plot, the fit was not very good and there were indications of a second period.



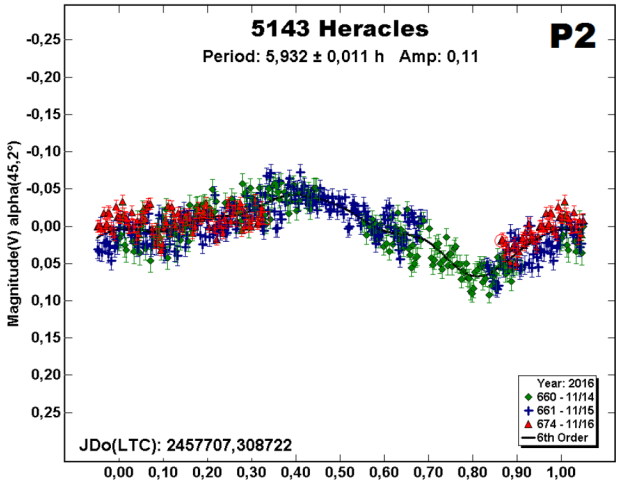
We used the dual-period search utility in *MPO Canopus* to see if there was a second period in the lightcurve. From this, we found the same dominant period, P_1 = 2.708 h, but the fit the Fourier curve was much improved ("P1") after subtracting a second period of P_2 = 5.932 h with an amplitude of 0.11 mag.

The second period is too short to be the orbital period of a satellite, unless the double-period near 11.8 h is adopted. Even so, the shape of the P_2 lightcurve does not show obvious signs of mutual events (occultations/eclipses) caused by a satellite.



Number	Name	2016 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
5143	Heracles	11/14-11/16	540	43.8,46.9	75	25	2.708	0.002	0.22	0.001	NEA
10150	1994 PN	07/15-07/17	301	35.5,36.4	261	28	2.959	0.005	0.34	0.003	NEA
12538	1998 OH	11/11-11/17	342	4.2,9.0	44	-5	5.088	0.004	0.11	0.004	NEA
66391	1999 KW4	06/19-06/21	475	81.4,83.0	257	57	9.581	0.019	0.27	0.018	NEA
257838	2000 JQ66	09/01-09/20	419	10.1,15.5	340	6	11.075	0.004	0.49	0.005	NEA
331471	1984 QY1	06/22-06/24	292	43.1,41.6	236	25	11.990	0.045	0.49	0.050	NEA
347813	2002 NP1	08/23-08/24	401	21.0,21.0	322	-7	5.907	0.004	0.73	0.004	NEA

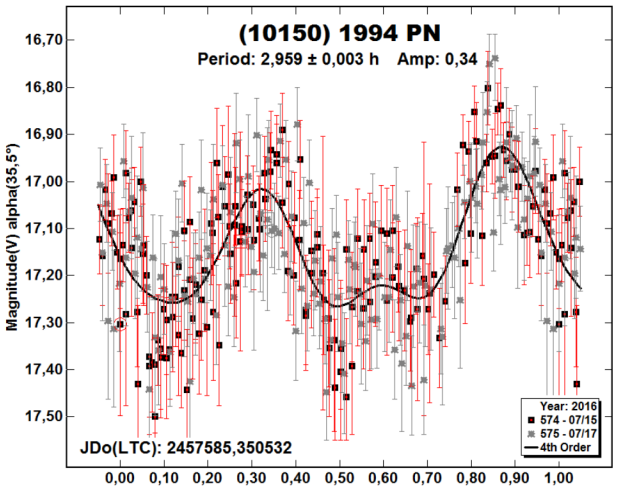
Table I. Observing circumstances and results. Pts is the number of data points. The phase angle values are for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). Grp is the asteroid family/group (Warner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



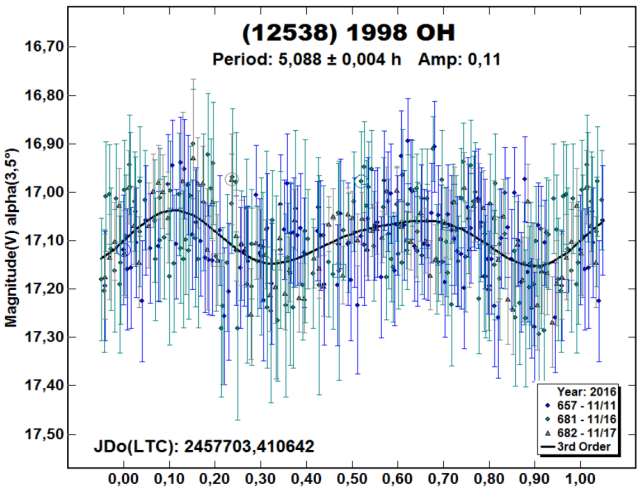
There is the possibility that the second period is due to low-level tumbling of a single body (see Pravec et al., 2005). To prove this would require more data than we had.

Even if the real cause of the two periods cannot be determined, they do seem real and not caused by problems with the images or analysis. This asteroid should be carefully watched at future apparitions with observations made over a week or more to be sure there are enough data.

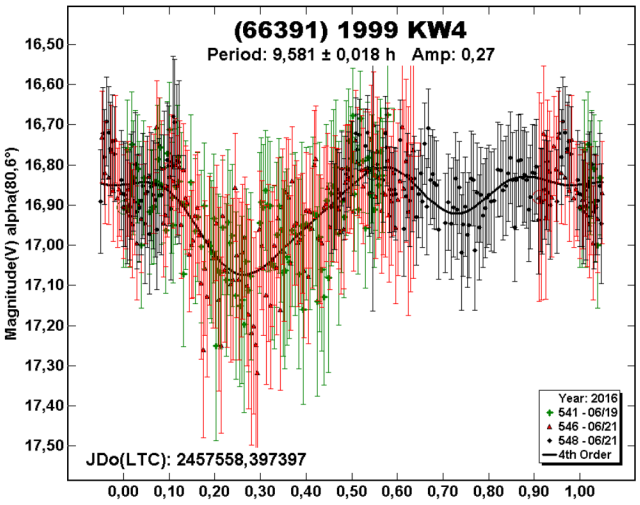
(10150) 1994 PN. This near-Earth asteroid was discovered on 1994 Aug 7 by G.J. Garradd at Siding Spring. The OBAS group made observations on two nights in 2016 July. From our data we derive a rotation period of 2.959 ± 0.003 hours and amplitude of 0.34 magnitudes. This result is consistent with the period of 2.965 h found by Warner (2016b).



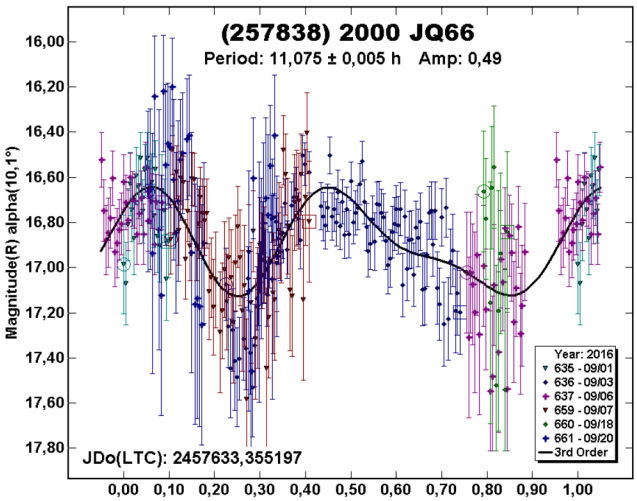
(12538) 1998 OH is an NEA that was discovered 1998-July-18 by NEAT. The OBAS group, especially the team at CAAT, obtained observations on three nights in 2016 November. From our data, we found a rotation period of 5.088 ± 0.004 h and amplitude of 0.11 mag. The period is similar to the 5.154 h found by Warner (2017b).



(66391) 1999 KW4. This NEA was discovered on 1999 May 20 by LINEAR at Socorro. The OBAS group, especially the team at CAAT, obtained observations on three nights in 2016 June. From our data, we found a rotation period of 9.581 ± 0.018 h and amplitude of 0.27 mag. This disagrees with the period of 2.7650 h found by Pravec et al. (2006), who reported this to be a binary asteroid with the satellite's orbital period being 17.45 h.

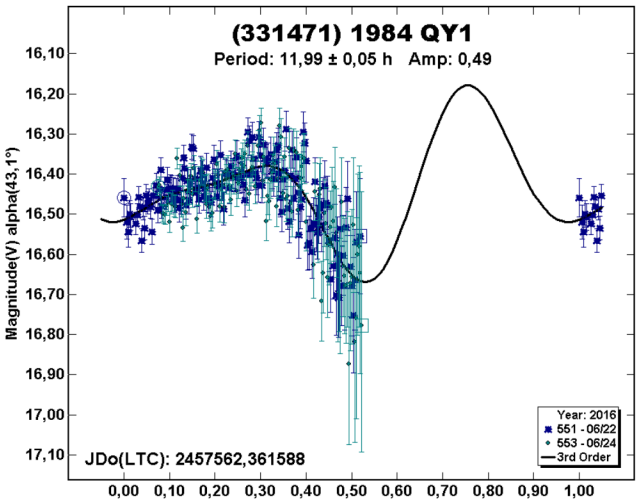


(257838) 2000 JQ66. This NEA was discovered on 2000 May 11 by LINEAR at Socorro. The OBAS group, especially Elche Observatory (MPC I57, *http://observatorioelche.blogspot.com.es),* made observations on six nights in 2016 September. From our data, we found a rotation period of 11.075 ± 0.005 h and amplitude of 0.49 mag. The period is consistent with the 11.094 h found by Warner (2017a).

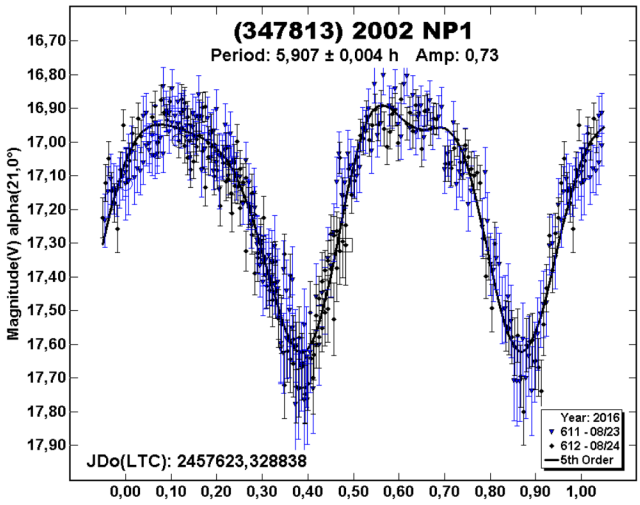


(331471) 1984 QY1. This NEA was discovered on 1984 Aug 27 by Helin and Rose at Palomar. The OBAS group made observations on two nights in 2016 June. The sky motion of the asteroid was 3 arcseconds/min, which required keeping exposures to less than 60 seconds.

From our data, we derived a rotation period of 11.99 ± 0.05 h and amplitude of 0.49 mag. The period differs from the 45.5 h found by Warner and Benishek (2016a), who reported that the asteroid was tumbling and that 36.6 h was a possible solution for the second period.



(347813) 2002 NP1 is an NEA. It was discovered on 2002 Jul 5 by LINEAR at Socorro. The OBAS group made observations on two nights in 2016 August. From our data, we derive a rotation period of 5.907 ± 0.004 h, which is consistent with the period of 5.915 h found by Warner (2017a).



Acknowledgements

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PERIOD DETERMINATION OF MAIN-BELT ASTEROID (26274) 1998 RH75

Johnny Eugene Brown Jr.
Department of Earth and Space Sciences
Columbus State University
4225 University Avenue
Columbus, GA 31907 USA

Tyler Linder
Astronomical Research Institute (H21/807)
Ashmore, IL USA
University of North Dakota, Grand Fork, ND USA

Dr. Andrew Puckett
Columbus State University
Columbus, GA USA

Robert Holmes
Astronomical Research Institute (H21/807)
Ashmore, IL USA

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Photometric observations of the inner main-belt asteroid (26274) 1998 RH75 were made on three nights in 2016 March. Analysis gave a bimodal lightcurve with a synodic period of 3.1296 ± 0.0001 h and amplitude of 0.55 ± 0.02 mag.

(26274) 1998 RH75 (also designated 2000 AM204) was selected as a target for photometric observations because Carvano *et al.* (2010) classified it as a C_p, L_p, and Q_p type asteroid. Obtaining lightcurve data was the next step to better understand this 3-4 km diameter, high inclination (12.39°; MPC, 2016) asteroid.

Observations were obtained at Cerro Tololo Inter-American Observatory using a 0.41-m *f*/10 Skynet PROMPT 2 telescope and an Andor Aspen CG230 CCD camera with a 15 µm 2048x2048 array. The system has an image scale of 0.75 arcsec/pixel and a field-of-view of 25.76x25.76 arcminutes. We used differential photometry through *MPO Canopus* software (Warner, 2011) for our lightcurve analysis. *MPO Canopus* reported the period and its uncertainty to a precision of 0.0001 h when we determined the period with the lowest RMS value.

Our result of P = 3.1296 h puts 1998 RH75 well within range of other main-belt asteroid periods. It showed no abnormalities in the lightcurve during its rotation. There were no reports on 1998 RH75 in the Asteroid Lightcurve Database (Warner *et al.*, 2009).

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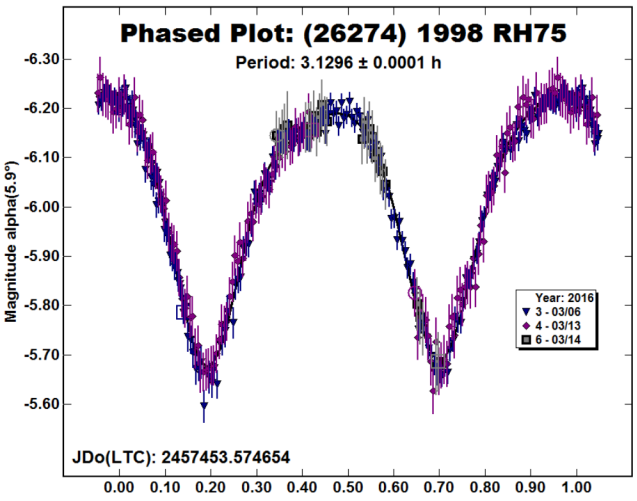

Number	Name	2016 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
26274	1998 RH75	03/06-03/14	360	6.0,1.7	176	-2	3.1296	0.0001	0.55	0.02	MB-I

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).