

PHOTOMETRY OF NEA (285263) 1998 QE2 DURING ITS 2013 CLOSE APPROACH

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We present a new rotational lightcurve and period/amplitude determination for NEA (285263) 1998 QE2 from photometric data obtained during four consecutive nights in June 2013, when the asteroid was between 0.04 and 0.05 au from Earth. The results are: $P = 4.7589 \pm 0.0119$ h and $A = 0.21 \pm 0.03$.

Near-Earth asteroid (285263) 1998 QE2 was discovered in August 1998 by the LINEAR facility at Socorro, NM (Williams, 1998). In early June 2013 the asteroid made its closest approach to the Earth (0.039 au) until 2221. At that time, it became as bright as $V = 11$ mag and was subjected to intense observational scrutiny. Radar observations (Springmann et al., 2014) showed the asteroid to be ~ 3 km in diameter and thus one of the largest Potentially Hazardous Asteroids known to-date. The radar data also indicated the presence of a satellite ~ 800 m in diameter with an orbital period of 31.3 ± 0.1 h (Pravec, 2013).

Reflectance spectroscopy (Hicks et al., 2013; Lin et al., 2018; Binzel et al., 2019; Fieber-Beyer et al., 2020) shows a taxonomically primitive surface, consistent with an albedo of ~ 0.04 obtained from measurements of the asteroid's thermal emission (Trilling et al., 2010; Fieber-Beyer et al., 2020).

An examination of the Asteroid Lightcurve Database (LCDB) (Warner et al., 2009; retrieved 2022 Aug 18) yielded four previous rotational period determinations for this asteroid, based on data obtained during the 2013 close approach. Those by Pravec (2013; $P = 4.749 \pm 0.001$ h, $A = 0.19 \pm 0.02$ mag) and by Hills (2014; $P = 4.751 \pm 0.002$ h, $A = 0.20 \pm 0.03$ mag) are mutually consistent, the remaining two are by Hicks et al. (2013; $P = 5.39 \pm 0.02$ h) and by Oey (2014; $P = 2.726 \pm 0.001$ h, $A = 0.11 \pm 0.01$ mag).

Here we present a photometric analysis of observations obtained with the 0.4-m f/8 Cassegrain reflector equipped with an SBIG ST-10 CCD and Johnson V filter at the University of Athens Observatory (UOAO) within the Department for Astrophysics, Astronomy and Mechanics at the National and Kapodistrian University of Athens (Gazeas, 2016) on 4 consecutive nights during the period 2013 June 2-5. Series of 30-s exposures were obtained every 35 s on the first two nights, switching to a 45 s cadence and 40-s exposure time for the remainder of the observing period as the

asteroid faded from $V = 11.4$ mag to $V = 12.1$ mag. All CCD frames were acquired with 2×2 on-the-fly binning and an effective image scale of 1.4 arcsec/pix.

For data analysis, the raw FITS frames were dark-subtracted and flat-fielded using subroutines from the *IDL Astronomy User's Library* (astrolib; Landsman, 1993).

Differential photometry was carried out with *MPO Canopus v10.7.6.4* (Warner, 2016) using solar analog comparison stars from the *MPOSC3* catalog. Due to the asteroid's rapid sky motion (20 arcsec/min on the 2nd June, slowing to 13 arcsec/min on the 5th) which necessitated shifting the imaging field several times on every night, the dataset was split into groups of several tens of frames each prior to photometric reduction. Lightcurve analysis was done with the Fourier algorithm by Harris and Lupishko (1989).

The period spectrum from 19 measurement groups spanning all four nights (Fig. 1) shows the most significant RMS minima in the range [0.2-10.5] h, used as a guide to perform a high-resolution period search in the interval [4.5-5.0] h with a period step of 0.001 h. Figure 2 shows a 6th order Fourier series (black curve) fitted to those data. Our best-fit estimate of the primary rotation period from the fit is $P = 4.7589 \pm 0.0119$ h with a corresponding estimate of $A = 0.21 \pm 0.03$ mag for the lightcurve amplitude. These are within 1-sigma of the Pravec and of the Hills et al. estimates, increasing confidence in a primary rotational period and lightcurve amplitude solution of $P \approx 4.75$ h and $A \approx 0.20$ for this asteroid. No attempt was made to search for secondary periods in the data.

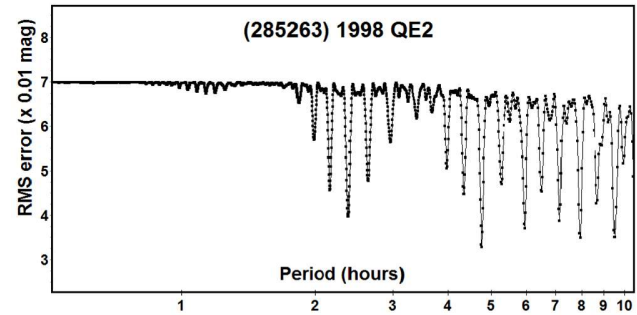


Figure 1: Period spectrum of (285263) 1998 QE2.

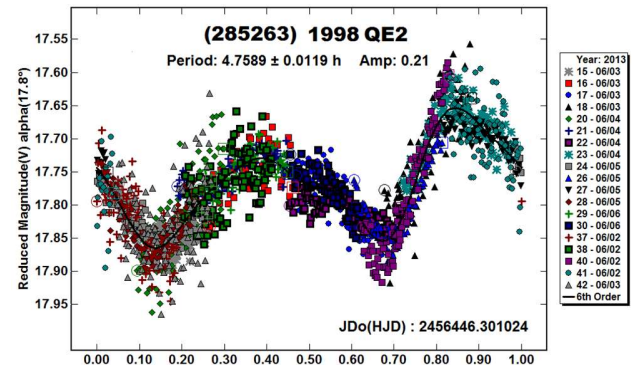


Figure 2: Phased lightcurve for (285263) 1998 QE2.

Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
285263	1998 QE2	2013 06/02-06/06	17.4, 23.8	248	8	4.7589	0.0119	0.21	0.03	NEA

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 an extrema 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).

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References

- Binzel, R.P.; DeMeo, F.; Turtelboom, E.V.; Bus, S.J. and 16 co-authors (2019). "Compositional distributions and evolutionary processes for the near-Earth object population: Results from the MIT-Hawaii Near-Earth Object Spectroscopic Survey (MITHNEOS)." *Icarus* **324**, 41-76.
- Fieber-Beyer, S.K.; Karetta, T.; Reddy, V.; Gaffey, M.J. (2020). "Near-earth asteroid: (285263) 1998 QE2." *Icarus* **347**, article id. 113807.
- Gazeas, K. (2016). "The robotic and remotely controlled telescope at the University of Athens Observatory." *Rev. Mex. Astron. Astroph. Ser. Conf.* **48**, 22-23.
- Harris, A.W.; Young, J.W.; Scaltriti, F.; Zappala, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.
- Harris, A.W., Lupishko, D.F. (1989). "Photometric lightcurve observations and reduction techniques." In: Asteroids II; Proceedings of the Conference, ed. R.P. Binzel, T. Gehrels, and M.S. Matthews, University of Arizona Press, p. 39-53.
- Hicks, M.; Lawrence, K.; Chesley, S.; Chesley, J.; Rhoades, H.; Elberhar, S.; Carcione, A.; Borlase, R. (2013). "Palomar spectroscopy of near-earth asteroids 137199 (1999 KX4), 152756 (1999 JV3), 163249 (2002 GT), 163364 (2002 OD20), and (285263) 1998 QE2." *The Astronomer's Telegram* **5132** (1).
- Hills, K. (2014). "Asteroid Lightcurve Analysis at Riverland Dingo Observatory (RDO): 2013 Results." *The Minor Planet Bulletin* **41**, 2-3.
- Landsman, W.B. (1993). In: *Astronomical Data Analysis Software and Systems II*, A.S.P. Conference Series, **52**, ed. R.J. Hanisch, R.J.V. Brissenden, and Jeannette Barnes, p.246. Available at <https://idlastro.gsfc.nasa.gov/>
- Lin, C.-S.; Ip, W.-H.; Lin, Z.-Y.; Cheng, Y.-C.; Lin, H.-W.; Chang, C.-K. (2018). "Photometric survey and taxonomic identifications of 92 near-Earth asteroids." *Planetary and Space Science* **152**, 116-135.
- Oey, J. (2014). "Lightcurve Analysis of Asteroids from Blue Mountains Observatory in 2013." *The Minor Planet Bulletin* **41**, 276-281.
- Pravec, P. (2013). Information retrieved on September 2022 by querying the Asteroid Lightcurve Photometry Database (ALCDEF: <https://alcdef.org>) for all available data on this asteroid.
- Springmann, A.; Taylor, P.A.; Howell, E.S.; Nolan, M.C.; Benner, L.A.M.; Brozovic, M.; Giorgini, J.D.; Margot, J.L. (2014). "Radar shape model of binary near-earth asteroid (285263) (285263) 1998 QE2". In: *Proc. Lunar Sci. Conf.* **45**, 1777, p. 1313.
- Trilling, D.E.; Mueller, M.; Hora, J.L.; Harris, A.W.; Bhattacharya, B.; Bottke, W.F.; Chesley, S.; Delbo, M.; Emery, J.P.; Fazio, G.; Mainzer, A.; Penprase, B.; Smith, H.A.; Spahr, T.B.; Stansberry, J.A.; Thomas, C.A. (2010). "ExploreNEOs I: description and first results from the warm Spitzer near-earth object survey." *Astron. J.* **140** (3), 770-784.
- Warner, B.D. (2016). MPO Software, MPO Canopus v10.7.6.4. BDW Publishing. <http://bdwpublishing.com/mposoftware.aspx>
- Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2021 Dec. <http://www.minorplanet.info/lightcurvedatabase.html>
- Williams, G.V. (1998). "MPEC 1998-Q19: 1998 QE2." IAU Minor Planet Center. Issued 1998 August 22.