

ASTEROID LIGHTCURVES FROM XINGMING OBSERVATORY: 2016 - 2017 JUNE

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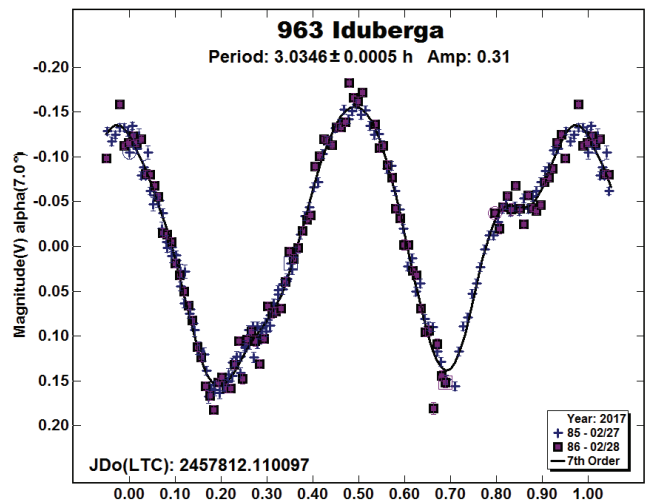
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The lightcurves of main-belt asteroids 963, 1025, 2019, and 17814 and near-Earth asteroids (NEAs) 459872, 2014 JO25, and 2017 BS32 were obtained using Xingming Observatory (Code C42) from 2016 March to 2017 March. The absolute magnitudes of these asteroids range from $H = 11.6$ to 27.3 , corresponding to a diameter range of ~ 14 m to 14 km. The derived synodic rotation periods range between 0.1 to 10 h.

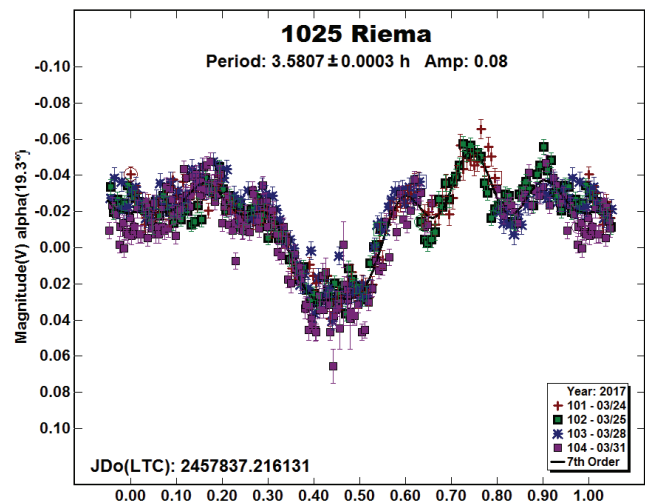
CCD photometric observations of five main-belt and three near-Earth (NEA) asteroids were made at the Xingming Observatory (IAU Code C42) from 2016 March to 2017 March. The observations were made with a 0.36-m telescope (C14) equipped with a QHY9 CCD (3.4Kx2.5K; 0.9 arcsec/pixel) and with a 0.5-m telescope equipped with a QHY11 CCD (4Kx2.6K pixels; 1.8 arcsec/pixel). All images were taken without a filter and binned 2x2 to enhance the signal and then calibrated using standard procedures, including flat-correction and dark and bias frames using *Maxim DL*. Relative photometry was obtained using *MPO Canopus* with an aperture optimized to each image seeing. The Fourier period analysis, also available in *MPO Canopus*, was then applied to the lightcurve data.

963 *Iduberga* was discovered by Karl Wilhelm Reinmuth on 1921 Oct 26 at Heidelberg, Germany. According to the details in the LCDB (Warner et al., 2009), *Iduberga* is an S-type main-belt asteroid. After two nights of observations, we found a rotation

period $P = 3.0346 \pm 0.0005$ h and amplitude $A = 0.31$ mag. This confirms Behrend's result (2010) listed in the LCDB.



1025 *Riema* was first discovered by Karl Wilhelm Reinmuth on 1923 Aug 12 at Heidelberg. Analysis of our observations obtained from 2017 Mar 24-27 provide a good fit to a lightcurve with $P = 3.5807 \pm 0.0003$ h and $A = 0.08$ mag.

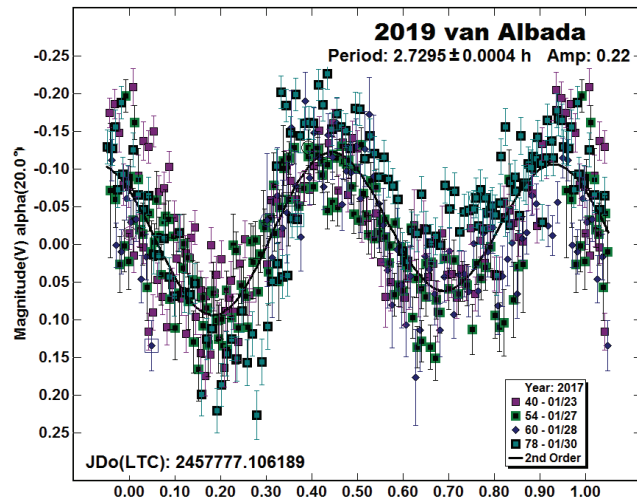


Although six similar rotational periods have been published by Stephens (2003), Warner (2009, 2013, 2014, 2016, 2017), and Behrend (2017), the unusual shape of our lightcurve is totally different from those in the previous works. Additional observations of this asteroid are recommended.

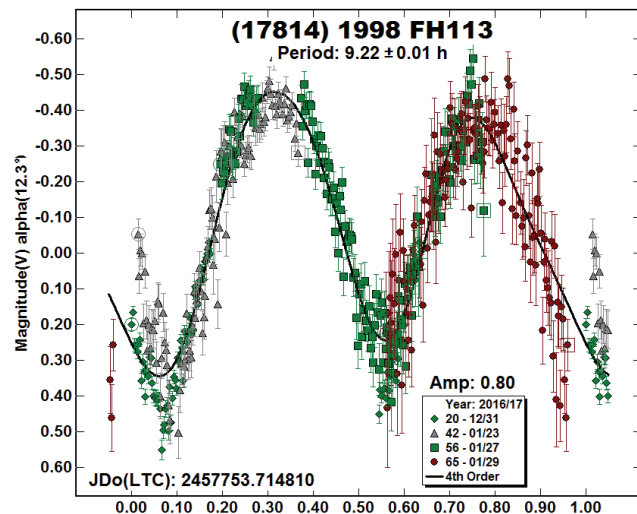
Number	Name	20yy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Group
963	<i>Iduberga</i>	17/02/27-02/28	7.0, 6.7	164	11	3.0346	0.0005	0.31	0.02	FLOR
1025	<i>Riema</i>	17/03/24-03/31	19.4, 18.2	204	23	3.5807	0.0003	0.08	0.01	H
2019	van Albada	17/01/23-01/30	19.8, 20.9	70	-1	2.7295	0.0004	0.22	0.03	FLOR
17814	1998 FH113	16/12/31-17/01/29	12.0, 17.8	67	-1	9.22	0.01	0.80	0.04	EOS
459872	2014 EK24	16/02/29	28.8	144	3	0.0999	0.0001	0.76	0.04	NEA
	2014 JO25	17/04/24-04/28	24.9, 26.9	200	-5	4.530	0.002	0.23	0.02	NEA
	2017 AG5	17/01/07	13.1	102	6	-	-	>0.05	-	NEA
	2017 BS32	17/02/02	17.7	138	7	0.179	0.001	0.20	0.02	NEA

Table I. Observing circumstances and results. The phase angle (α) is given at the start and end of each date range. L_{PAB} and B_{PAB} are, respectively, the average phase angle bisector longitude and latitude (see Harris et al., 1984). The Group column gives the orbital group to which the asteroid belongs. The definitions and values are those used in the LCDB (Warner et al., 2009a). FLOR = Flora; H = Hungaria.

2019 Van Albada is a main-belt asteroid discovered by H. van Gent at Johannesburg on 1935 Sep 28. We observed it on four nights between 2017 Jan 23-30. We obtained a synodic period of $P = 2.7295 \pm 0.0004$ h and amplitude of $A = 0.22$ mag. This period is in excellent agreement with past results (Liu, 2015; Waszczak et al., 2015).

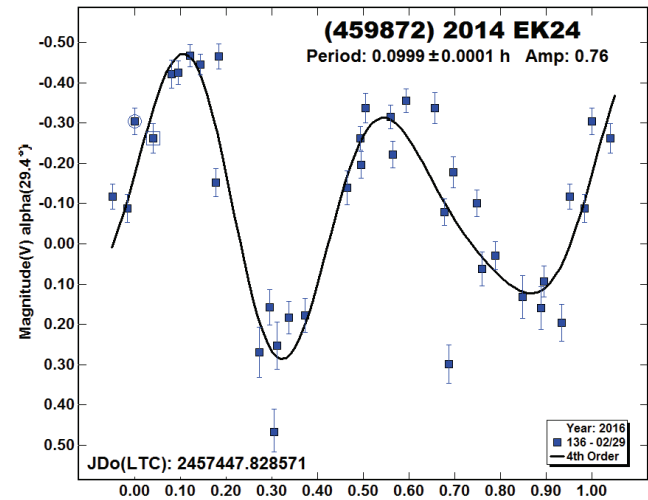


(17814) 1998 FH113 is a main-belt asteroid discovered on 1998 Mar 31 by LINEAR. The only previously published period is by Behrend (2015): 10.11 h and amplitude of 0.39 mag. Our first session was obtained on 2016 Dec 31. Due to strong moonlight and bad weather, we didn't resume observations until 2017 Jan 23. The data analysis shows a bimodal lightcurve with a synodic rotation period of $P = 9.22 \pm 0.01$ h and amplitude of $A = 0.80$ mag, which disagrees with Behrend (2015). Further observations are needed to confirm an accurate rotation period.

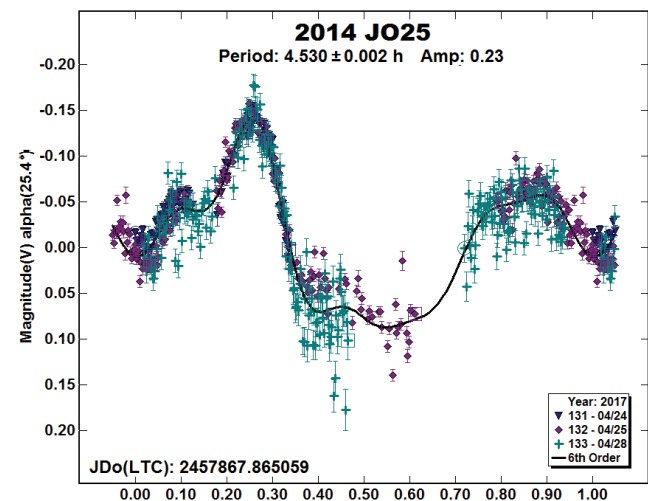


(459872) 2014 EK24 is an Apollo type NEA ($D \sim 70$ m), originally discovered on 2014 Mar 10 by CSS at Haleakala. From the two close approaches with Earth in 2014 and 2015, there are six previous rotation periods given in the LCDB, all of them near 0.099 h (e.g., Godunova 2016; Thirouin 2016). We found a synodic period of $P = 0.0999 \pm 0.0001$ h and amplitude $A = 0.76$ mag. These values are consistent with the previously published results. (459872) 2014 EK24 takes less than 6 minutes to complete one rotation and has a diameter of about 70 m. Its fast rotation may result from the YORP effect (Rubincam, 2000). Because of

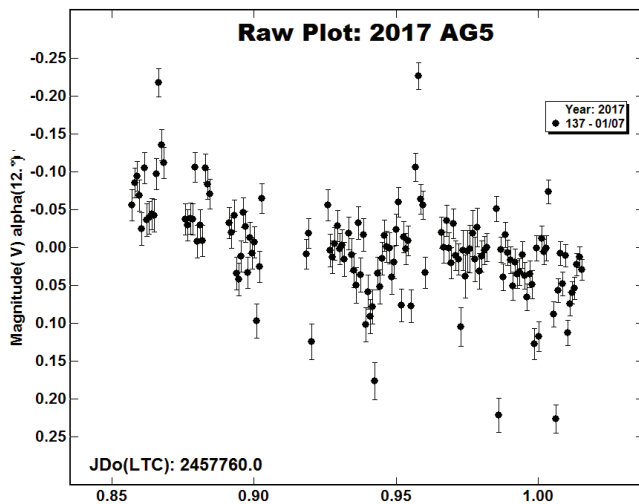
its small size and fast rotation, it may be an impact ejecta that escaped from a larger parent body (Urakawa et al., 2014).



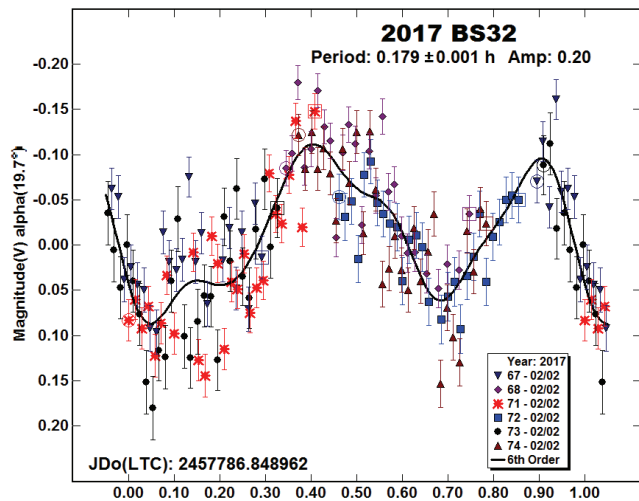
2014 JO25 is a large ($D \sim 650$ m) Apollo type NEA and potentially hazardous asteroid (PHA). It passed by Earth on 2017 April 20 at a distance 4.6 lunar distances. During our observations from 2017 Apr 24-28, the asteroid receded from the Earth but the phase angle and viewing aspects did not change much. As a result, the lightcurves on Apr 24, 25, and 28 have very similar appearances and amplitudes. We didn't see the day-to-day evolution in our observations as others did (Warner, 2017). Due to bad weather, low altitude, and instrument problems, we observed this NEA for only a short time and didn't cover all its period. The best period of the combined data, using a sixth-order Fourier fit, is $P = 4.530 \pm 0.002$ h, $A = 0.23$ mag. Our rotation period is consistent with the results obtained from Arecibo and Goldstone radar observations and some previous results by Warner (2017) and Behrend (2017).



2017 AG5 is an Apollo type NEA ($D \sim 140$ m) discovered on 2017 Jan 5 by the Mt. Lemmon Survey. We observed this NEA for about 3.5 hours on 2017 Jan 7 and found no hint of an apparent period. No previous results were found in the LCDB.



2017 BS32 is a bus-size ($D \sim 12$ m) Aten type NEA with no reported period in the LCDB. It flew by the Earth at a distance of 0.4 lunar distances in 2017 Feb. Because the NEA was rapidly receding from Earth, our observing window was only one night. Using the 0.5-meter telescope with exposures of only 0.5 s, the NEA still moved rapidly in our field. The result of our analysis was a lightcurve with a period of $P = 0.179 \pm 0.001$ h and amplitude of about 0.20 mag.



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