LIGHTCURVE ANALYSIS OF THE NEAR-EARTH ASTEROID 2015 CN13

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The near-Earth asteroid 2015 CN13 made a fly-by of Earth in late 2015 February. We observed the asteroid on Feb 25, 26, and 28. Analysis of the data set found two possible periods, the most likely being $P = 22.7 \pm 0.3$ h. Given the estimated diameter of 70 meters and long period, this puts 2015 CN13 in a small group of NEAs with $D \leq 140$ meters and periods well below the spin barrier, *i.e.*, approximately $P \geq 2.2$ hours.

The near-Earth asteroid (NEA) 2015 CN13 made a fly-by of Earth in late 2015 February. It was V < 18.0 from about Feb 22- March 5, reaching a minimum of V ~ 16.9 on Feb 28. Given its sky motion and the size of telescopes available and, combined with a waxing moon beyond first quarter, there was only a small window of opportunity for making CCD photometry observations. With an estimated size of about 70 meters, the chances that the asteroid was a super-fast rotator, $P \ll 1$ hour, were high and so exposures had to be kept short in order to avoid *rotational smearing*, which is when exposures are a significant portion of the rotation period and so details about features within the lightcurve are lost (see Pravec *et al.*, 2000).

Tables I and II give the equipment used and the dates of observations for each observer. Exposures were 60 sec on Feb 25-26 and 30 sec on Feb 28. To keep the signal-to-noise as high as possible, no filters were used.

OBS	Telescope	Camera
Warner	0.30-m *f*/9.6 Schmidt-Cass	FLI ML-1001E
Oey	0.61-m *f*/6.8 CDK	Apogee U42

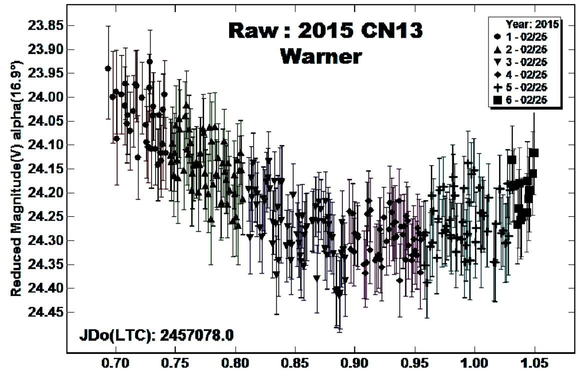
Table I. List of observers and equipment.

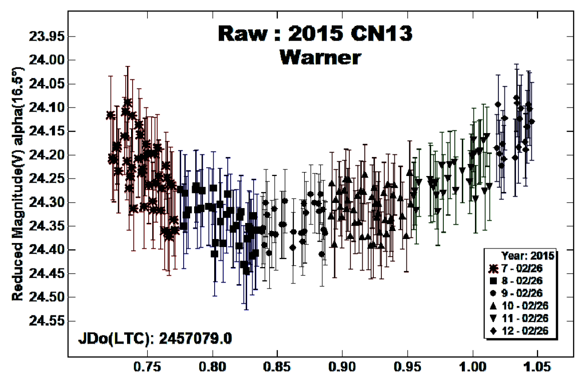
Obs	2015 mm/dd	Sess	α	L_{PAB}	B_{PAB}
Warner	02/25 26	1-12	17.1,16.4	160,163	8,6
Oey	02/28	13-15	20.2	170	1

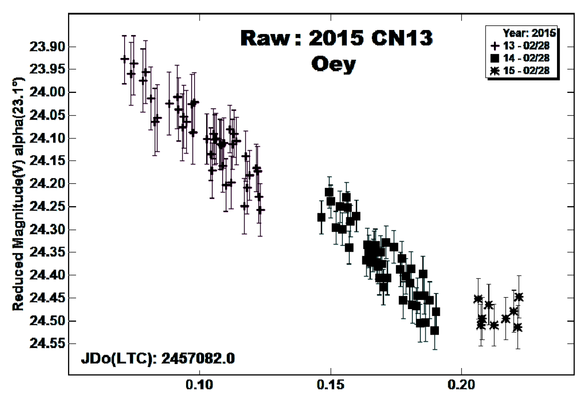
Table II. Dates of observation for each observer. a is the solar phase angle. The last two columns are the phase angle bisector longitude and latitude (see Harris *et al.*, 1984).

Both observers used *MPO Canopus* to measure the images. The Comp Star Selector utility in *MPO Canopus* found up to five solar-colored stars for each session. The magnitudes for the comparisons were taken from the MPOSC3 catalog, which is based on the 2MASS catalog converted to the BVRcIc system using formulae developed by Warner (2007). Oey sent his data to Warner for period analysis using *MPO Canopus,* which incorporates the FALC Fourier analysis algorithm developed by Harris (Harris *et al.,* 1989).

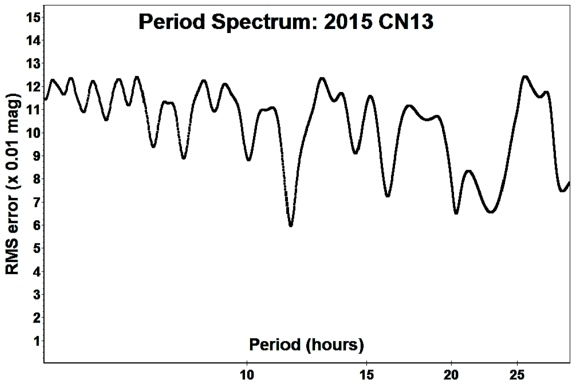
The raw plots for Feb 25 and 26 each show an apparent minimum in the lightcurve. Since the Feb 26 shifted the minimum to the left, a first estimate for the period was that it was a little less than being exactly commensurate with an Earth day, *e.g.*, between 11-12 or 23-24 hours. Given the shape of the raw curves, shorter periods near 6 and 8 hours were considered unlikely, but leaving the possibility for a period near 16 hours. Since the asteroid was within range for only a short period, there was no chance for a single station to get sufficient coverage of the total lightcurve to find a reasonably accurate period. This is where the observations from Oey, located about 110 degrees in longitude to the west of Warner's location, became critical.

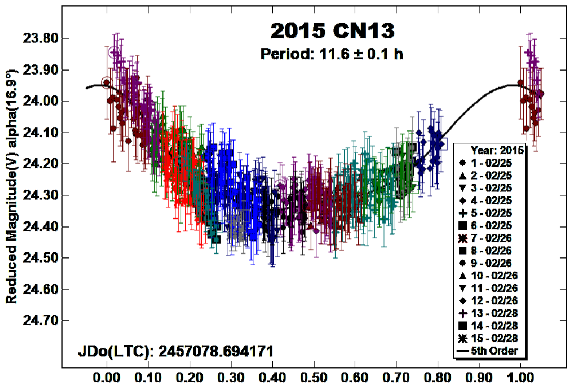


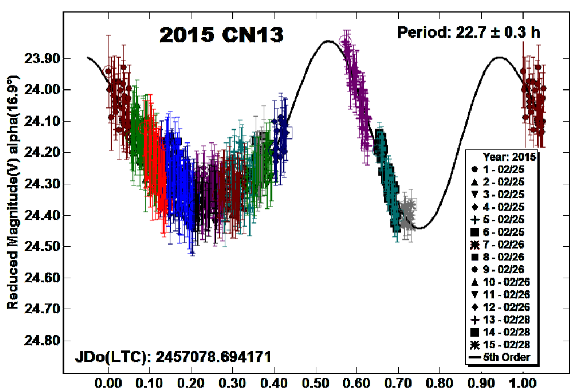




The data from Oey were obtained when the asteroid had an even larger sky motion and the moon was 3 days past first quarter, therefore there was some uncertainty about how well they would fit in with the other data. Fortunately, when combined with the data from the two previous sessions, they led to solutions that, as expected, were nearly commensurate with an Earth day, as seen in the period spectrum.





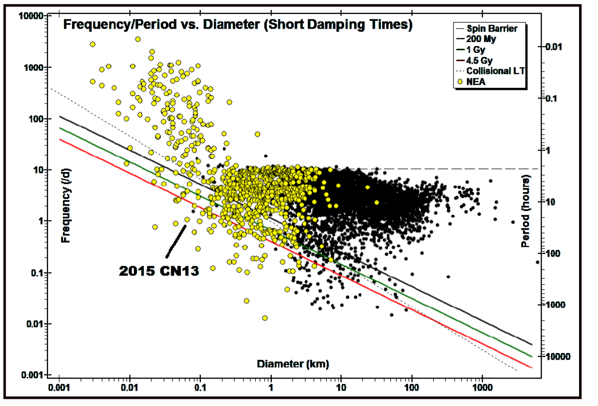


The two more likely periods were P = 11.6 ± 0.1 h, A = 0.40 ± 0.05 mag and P = 22.7 ± 0.3 h, A = 0.60 ± 0.05 mag. Given the moderate phase angle and large amplitude, the longer period is adopted for this paper (see Harris *et al.*, 2104).

Unfortunately, this was the only good chance for time-series photometry on 2015 CN13 for many years. From 1995-2050, this was the only apparition when then asteroid was V < 22.0. Radar observations for 2015 CN13 were canceled due to electronic problems (Lance Benner, private communications) so, unless there are other optical data of which we are unaware, verification of these results may be a long time coming.

The period makes the asteroid a little unusual but not particularly rare. A scan of the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) found 37 NEAs with $D \leq 140$ meters and $P \geq 2.2$ hours, or below the so-called *spin barrier* that roughly separates rubble pile from strength-bound asteroids. When setting $P \geq 10$ hours, the count drops to 11 NEAs. These numbers should be viewed with some caution. Since many NEAs are available for only short periods and often only once within a period of many years, there is likely a bias against slow rotating NEAs, *i.e.*, there may be (many) more objects with moderate to long periods.

The frequency-diameter plot based on the LCDB as of 2015 March 31 shows the location of 2015 CN13. NEAs are highlighted by yellow circles. The dotted horizontal line at about 2.2 hours is the *spin barrier*. The diagonal solid lines give the frequency vs. diameter for specific damping times, *i.e.*, the estimated time for a tumbling asteroid to return to single axis rotation.



Acknowledgements

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