

CCD PHOTOMETRIC OBSERVATIONS OF ASTEROIDS 2984 CHAUCER, (26206) 1997 PJ4, (87035) 2000 KE2, AND 2015 NU13

Kenneth Zeigler
Star Z Research Ranch
PO Box 1464, George West, Texas 78022 USA
Dylan_lucard@yahoo.com

(Received: 2021 June 11, Revised: 2021 August 2)

CCD photometric observations of asteroids 2984 Chaucer, (26206) 1997 PJ4, (87035) 2000 KE2, and 2015 NU13 were conducted from the Star Z Research Ranch in South Texas. The rotational period of asteroid 2984 Chaucer is 9.016 ± 0.010 h, with an amplitude of 0.98 mag. The rotational period of asteroid (26206) 1997 PJ4 is 3.293 ± 0.010 h with an amplitude of 0.13 mag. The rotational period of asteroid (87035) 2000 KE2 is 6.14 ± 0.01 h with an amplitude of 0.13 mag. The rotational period of asteroid 2015 NU13 is 2.4 ± 0.1 h, with an amplitude of 0.26 mag.

The photometric observations described in this paper were conducted from the Star Z Research Ranch, which is located at a dark sky site, 19 kilometers south of the Town of George West, Texas.

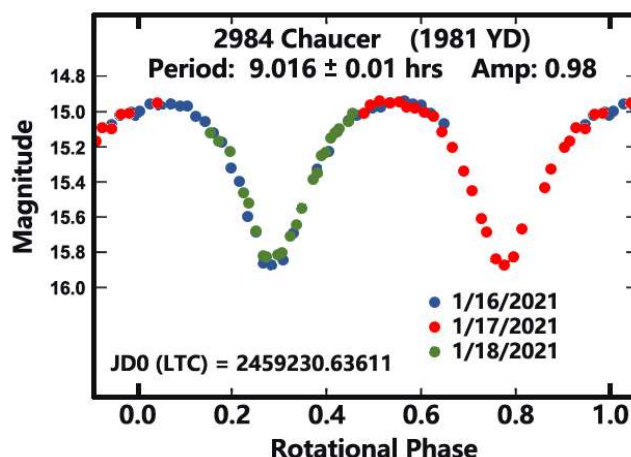
Throughout this research program, a Meade 0.35-meter LX600 Schmidt Cassegrain telescope was used. The telescope is housed within a converted eight by sixteen-foot Wells Cargo trailer with a hinged roof, which in turn sets upon four steel jacks resting on a concrete slab. The telescope pier itself rests upon a heavy steel tripod, independent of the trailer, to minimize vibrations. An SBIG STXL 6303 camera thermoelectrically cooled to -35°C was used to make the photometric observations. The photometric exposures were all 120 seconds in length and were dark subtracted and flat fielded. To preserve the maximum light intensity of the objects observed, no filters were placed in the optical path during the observations.

The brightness of the asteroid was compared to that of three comparison stars in the same CCD frame. The average instrumental magnitude of the three stars was determined and this average was subtracted from the instrumental magnitude of the asteroid. A constant was then added to approximate the visual magnitude. The instrumental magnitude of the three comparison stars with respect to one another was continuously monitored in the event that one of them was determined to be a short period variable star. The target brightness was determined by measuring a 121 pixels (11 pixel by 11 pixel) sample surrounding the asteroid or star in question. This corresponds to a 7.15 by 7.15 arcsec box. When possible, the same comparison stars were used during consecutive nights of observation. The coordinates of the asteroid and its approximate visual magnitude on any specific night were obtained from the

online Lowell Minor Planet Services. This information was also used to compensate for the effect of the asteroid's changing distance from the sun and earth on its visual magnitude when vertically aligning the photometric data points from different nights in the construction of a composite lightcurve.

2984 Chaucer was discovered by Edward Bowell at Lowell's Anderson Mesa Station in Flagstaff, Arizona, on 30 December 1981. It is named after Geoffrey Chaucer (1343–1400), the medieval English poet. The orbit of the asteroid has a semi-major axis of 2.500 a.u., eccentricity of 0.136, and an orbital period of 3.88 years. This places it within the inner region of the main belt. This asteroid was observed from the Star Z Research Ranch on three separate nights between January 16 and 18, 2021. The asteroid's lightcurve is characterized by two broad and nearly identical maxima, and two narrow minima per rotational cycle. A composite lightcurve with a period of 9.016 ± 0.01 h best fit the available data. The lightcurve has an amplitude of 0.98 mag, as shown in the figure.

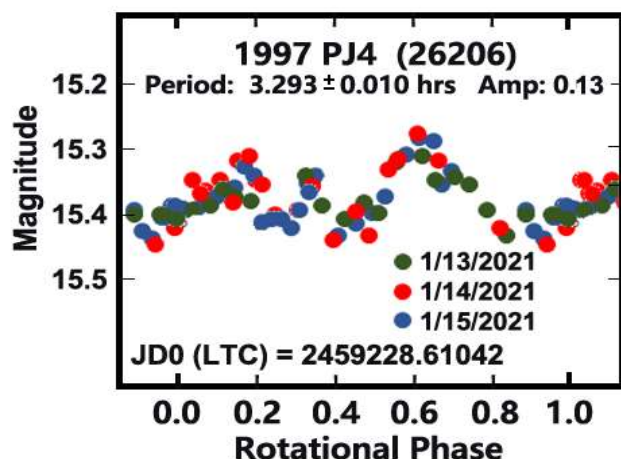
A search of the literature revealed no previously published rotational period for 2984 Chaucer.



(26206) 1997 PJ4 was discovered on 1997 Aug 11 by P. Antonini, at the Bedoin Observatory in Southern France. With a semi-major axis of 2.867 a.u., eccentricity of 0.138, and orbital period of 4.36 years it is located in the middle of the main belt. According to the Lightcurve Data Base, as of October 2020, a rotational period for this asteroid has not yet as been determined. This asteroid was observed from the Star Z Research Ranch on the nights of January 13, 14, and 15, 2021. The asteroid was determined to have a rotational period of 3.293 ± 0.010 h, with a lightcurve amplitude of 0.13 mag. The lightcurve is very asymmetrical, characterized by three separate maxima and minima per rotational cycle. The three minima are of approximately the same magnitude; however, the three maxima are not. Two are broad while the third is far narrower, lasting only a matter of minutes. This peculiar lightcurve feature was observed on all three nights of observation.

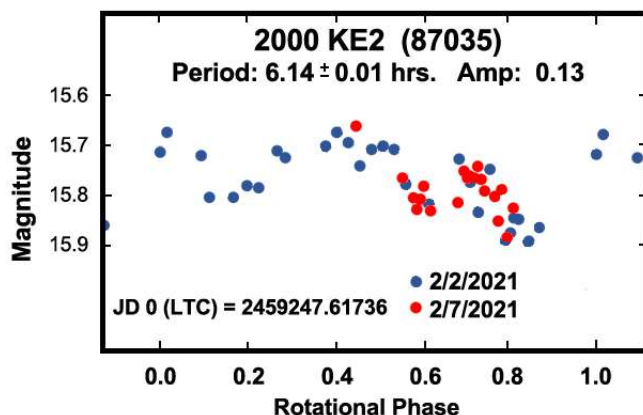
Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2984	Chaucer	2021 1/16-1/18	1.5, 2.2	116	3	9.016	0.010	0.98	0.02	
26206	1997 PJ4	2021 1/13-1/15	-2.5, 2.2	116	-5	3.293	0.010	0.13	0.02	
87035	2000 KE2	2021 2/2 -2/7	-3.8, 3.5	143	5	6.14	0.010	0.13	0.02	Amor
	2015 NU13	2021 1/23	-9.4, -9.3	123	-10	2.4	0.100	0.26	0.02	Apollo

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).



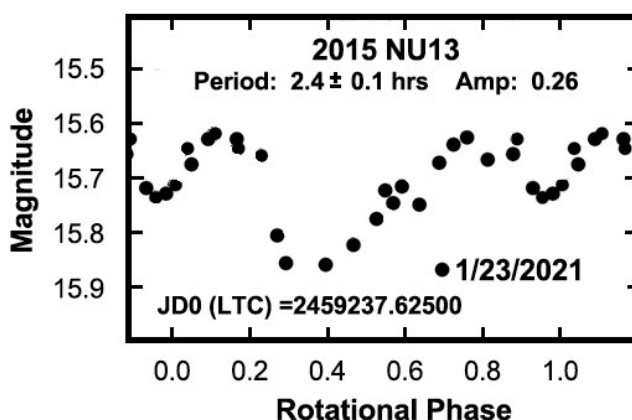
(87035) 2000 KE2 was discovered on 26-May-2000 by the LINEAR Survey at Socorro, New Mexico. Its orbit has a semi-major axis of 2.352 a.u., eccentricity of 0.343, and an orbital period of 3.61 years. Its high eccentricity makes it a Mars crossing asteroid. This asteroid was observed from the Star Z Research Ranch on the nights of February 2 and 7, 2021. At the time of observation, it was just beyond the orbit of Mars. It should be noted that the reported rotational period of this asteroid has some uncertainty associated with it. The composite lightcurve presented here is the most likely one, however there are other possibilities. The composite lightcurve is very asymmetrical displaying three minima and three maxima per rotational cycle. A rotational period of 6.14 ± 0.01 h, with a lightcurve amplitude of 0.13 mag best fits the observations, as shown in the figure.

According to the October 2020 update of the LCDB, Asteroid 87035, has, as yet, no published rotational period.



2015 NU13 is classified as an Apollo asteroid and also a potentially hazardous asteroid. Its orbit has a semi-major axis of 1.830 a.u., an eccentricity of 0.590, and an orbital period of 2.48 years. At perihelion it is just beyond the orbit of Venus. It has been estimated to be about half a kilometer in diameter. On 9-January-2021 it passed within 0.038 a.u. of Earth. However, at the time it had a far southern declination and was moving very rapidly across the sky. On the night of the observations, it was 0.126 a.u. from Earth and much further north. Its angular speed had slowed sufficiently to conduct CCD photometry. It was only observed during a single night, the other nights around this date being cloudy. Its lightcurve displays two maxima and two minima per rotational cycle. The maxima are of nearly identical brightness; however, one minimum is a full 0.1 mag fainter than the other. The asteroid was observed for a bit over one rotation before clouds moved in. An examination of the October 2020 update of the Asteroid Lightcurve Database reveals that this asteroid currently has no published lightcurve.

The single night lightcurve for this asteroid is shown in the figure.



References

- Harris, A.W.; Young, J.W.; Scaltriti, F.; Zappala, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gytis." *Icarus* **57**, 251-258.
- JPL (2018). Small Body Database Browser.
<http://ssd.jpl.nasa.gov/sbdb.cgi>
- Lowell Minor Planet Services.
<https://asteroid.lowell.edu/gui/>
- Warner, B.D.; Harris, A.W.; Pravec, P. (2009). "The Asteroid Lightcurve Database." *Icarus* **202**, 134-146. Updated 2020 Oct.
<http://www.minorplanet.info/lightcurvedatabase.html>