Feature Story: Minor Planets

Something Old, 'Something New': Three Binary Discoveries From the Palmer Divide Observatory

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This paper was published initially in *The Minor Planet Bulletin* Vol. 40, No. 3 (July-September 2013).

Its publication here is meant to demonstrate the good work being done by the ALPO Minor Planets Section and to inspire and recruit others to likewise participate.

While five-dollar contributions are most welcome, you may access *The Minor Planet Bulletin* at no charge online at *http://www.minor-planet.info/mpbdownloads.html*.

Abstract

Analysis of new CCD photometric observations in early 2013 of the Vestoid asteroid 4383 Suruga and Hungaria asteroid (53432) 1999 UT55 showed that the two are binary systems. A review of data from 2005 for the Hungaria asteroid 4440 Tchantches indicates that the original analysis probably overlooked a satellite.

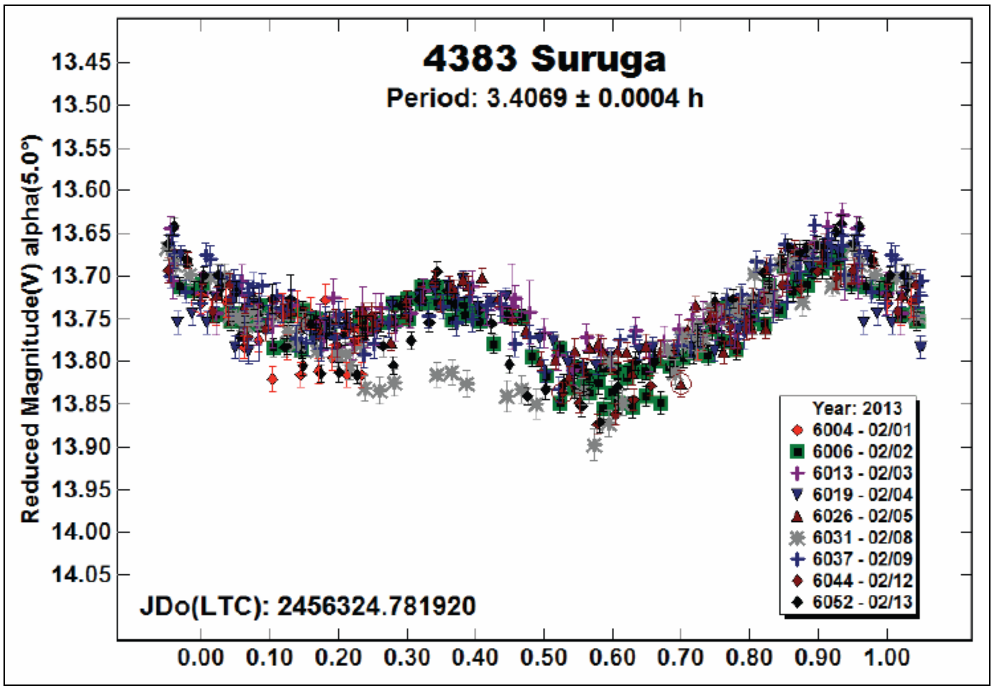

Figure 1. The unsubtracted lightcurve of 4383 Suruga.

Discussion

The Palmer Divide Observatory (PDO) observing program concentrates on the Hungaria asteroids. As such, CCD photometric observations of (53432) 1999 UT55 were made in early 2013. If a Hungaria asteroid is not available, then one of the five telescopes at PDO is used to observe other targets, either near-Earth asteroids (NEAs) or objects in the asteroid lightcurve database (LCDB; Warner et al, 2009) that have poorly-defined rotation periods. The latter was the case for 4383 Suruga, a Vestoid member, which was observed in 2013 February. Email discussions prompted a review of the original 2005 data set from PDO for the Hungaria asteroid 4440 Tchantches. As detailed below, all three objects were found to be binary systems.

All exposures in 2013 were guided, unfiltered, and 240 seconds. The images were measured in *MPO Canopus*. The dual-period feature in that program, based on the FALC algorithm developed by Harris et al. (1989) was used to subtract one of the periods from the data set in an iterative process until both periods remained stable. For the 2013 data sets, night-to-night calibration was accomplished using the Comp Star Selector feature in *MPO Canopus*. Catalog magnitudes for the comparison stars were derived from J-K to BVRI formulae developed by Warner (2007) using stars from the 2MASS catalog (Skrutskie et al, 2006). A description of this method was described by Stephens (2008).

Three figures are presented for each asteroid. The first shows the *unsubtracted* data set, meaning that the effects of the satellite have not been removed. The second figure shows the lightcurve of the primary, i.e., after removing the effects of the satellite. The third figure shows the lightcurve after removing the rotation of the primary, thus revealing the mutual events and other features due to the satellite. The latter often includes an upward bowing between the events, indicating an elongated satellite that is tidally locked to its orbital period.

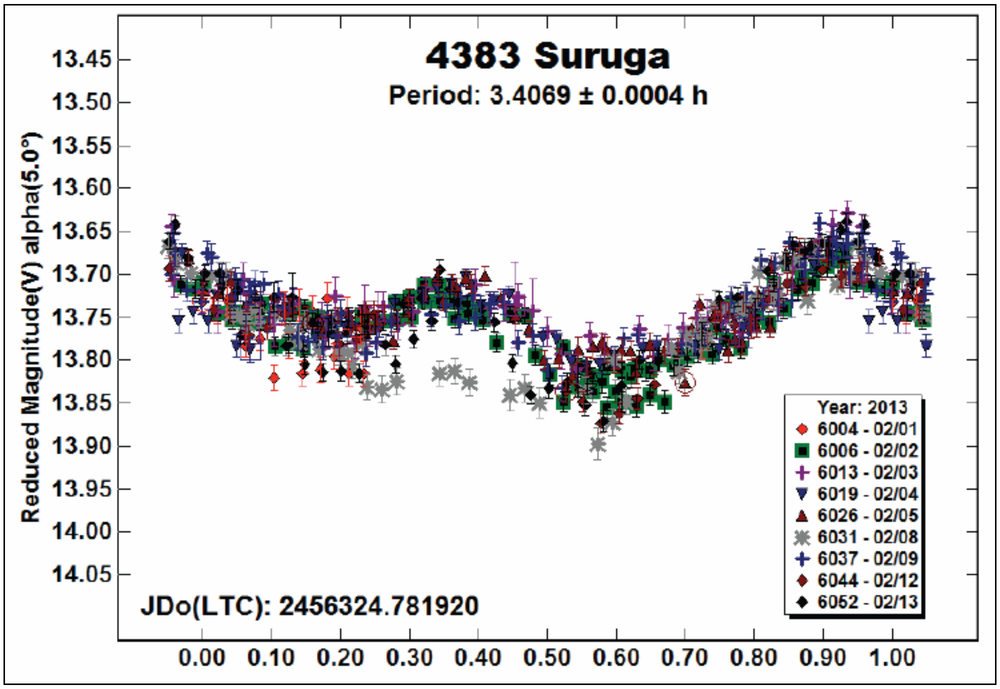

Figure 2. The lightcurve for the primary of 4383 Suruga.

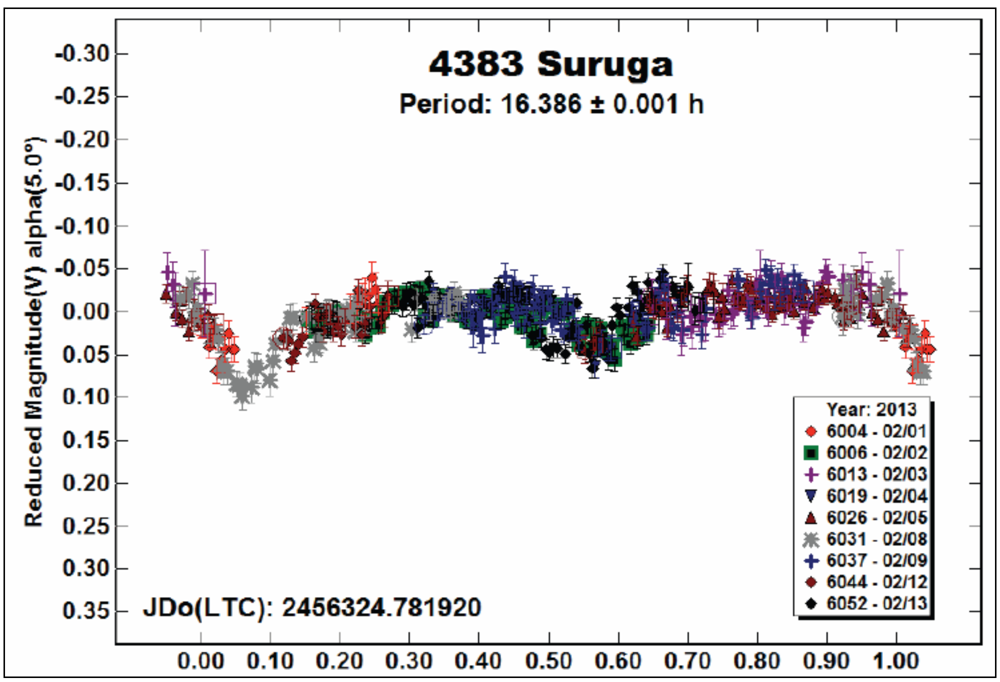

Figure 3. The lightcurve of 4383 Suruga showing the mutual events due to the presumed satellite.

4383 Suruga Observations of 4383 Suruga were made from 2013 Feb 2-13. Initial observations were made with a 0.35-m Schmidt-Cassegrain and Finger Lakes FLI-1001E CCD camera. When indications of a satellite were seen in those first data sets, the target was moved to a 0.5-m Ritchey-Chretien with FLI-1001E to improve the signal-to-noise ratio. Data on the order of 0.01-0.02 mag are usually required for reliable detections of mutual events (occultations and/or eclipses) caused by a satellite.

The results of the analysis are shown in Figures 1-3. The period of the primary is 3.4068 $\pm$ 0.0003 h with an amplitude of 0.14 $\pm$ 0.01 mag, indicating a nearly spheroidal shape. The orbital period of the satellite is 16.386 $\pm$ 0.001 h. The depths of the events are 0.1 and 0.05 mag. The shallower of the two is used to estimate the secondary-primary size ratio. In this case, the result is Ds/Dp $\geq$ 0.21 $\pm$ 0.02. Hasegawa et al. (2012) reported a period of 3.811 h and no indication of the object being binary.

4440 Tchantches This Hungaria asteroid had been observed several times before at PDO (Warner 2006, 2009, 2011) and by Behrend et al. (2002). In those cases, a period of about 2.78 h was reported. In Warner et al (2006), the possibility that the asteroid was binary was discussed and, based on an extensive observing campaign, the results were considered inconclusive.

Email discussions on an unrelated matter in 2013 put the original 2005 data set from PDO under review. In 2005, the observations were not calibrated from night-to-night but strictly relative, meaning that the assignment of zero points was arbitrary. The original plot using only PDO data seemed “suspicious” and so a new analysis was done whereby the zero points were shifted until a minimum RMS value from the Fourier analysis was found. This improved the fit from the original analysis significantly. Figure 4 shows the revised lightcurve. While relatively noisy, it did show signs similar to those caused by a satellite, i.e., somewhat prolonged and subtle deviations from the average curve.

Figure 6 shows a typical upward bowing with some “dips” spaced about 0.5 rotation phase apart. While the data are somewhat noisy, the result is considered sufficient to say that this is a binary asteroid. Assuming this is the case, the orbital period is 18.69 $\pm$ 0.05 h and the secondary-primary size ratio is Ds/Dp $\geq$ 0.25 $\pm$ 0.03. The primary rotation period was refined to 2.78836 $\pm$ 0.00004 h with an amplitude of 0.29 mag. This would make it among the more elongated primaries within the small binary population. Assuming an equatorial view and simple triaxial ellipsoid, the a/b ratio is about 1.3:1.

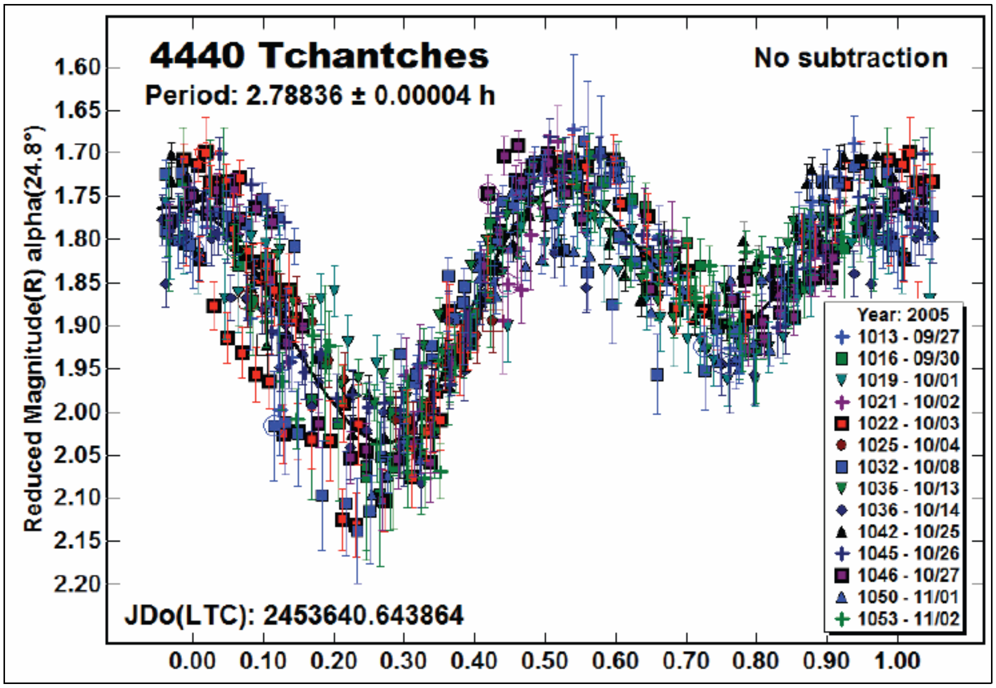

Figure 4. The unsubtracted lightcurve for 4440 Tchantches.

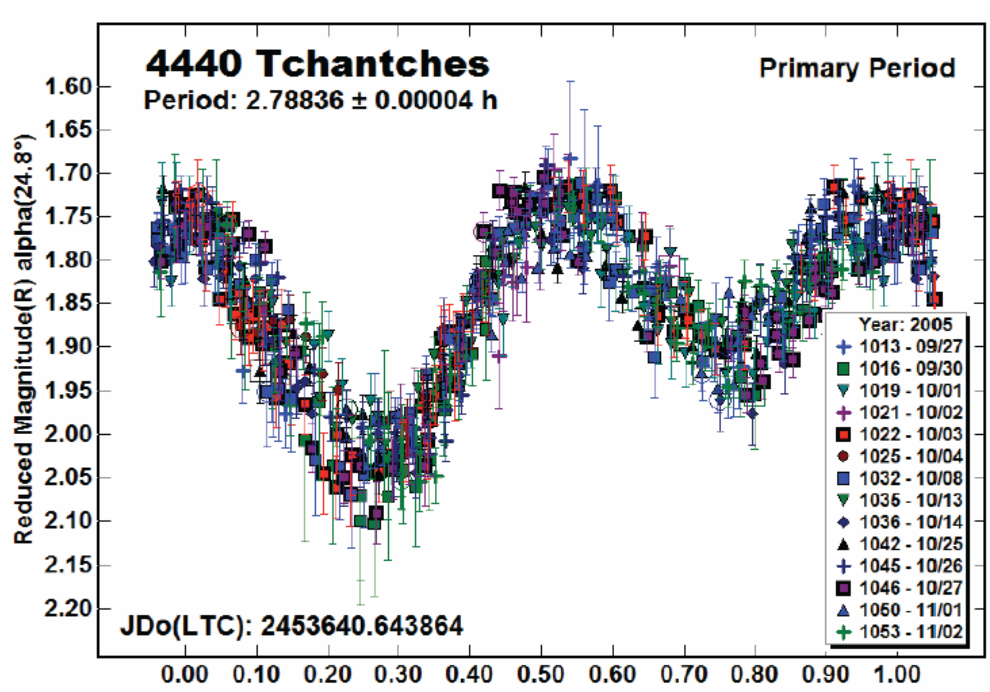

Figure 5. The primary lightcurve for 4440 Tchantches.

(53432) 1999 UT55 This Hungaria was observed for the first time from PDO from 2013 Jan 1-12. The 0.5-m Ritchey-Chretien with FLI-1001E CCD camera was used for all observations. Figure 7 shows what appeared to be a very noisy lightcurve, but still with some of the usual signs of a satellite. Part of the problem was that the asteroid was fainter than predicted and so the data are noisier than usually preferred.

The primary rotation period is P = 3.330 $\pm$ 0.002 h and amplitude A = 0.10 $\pm$ 0.01 mag. The orbital period of the satellite is 14.10 $\pm$ 0.01 h. The estimated secondary-primary size ratio is Ds/Dp $\geq$. 0.23 $\pm$ 0.02.

Acknowledgements

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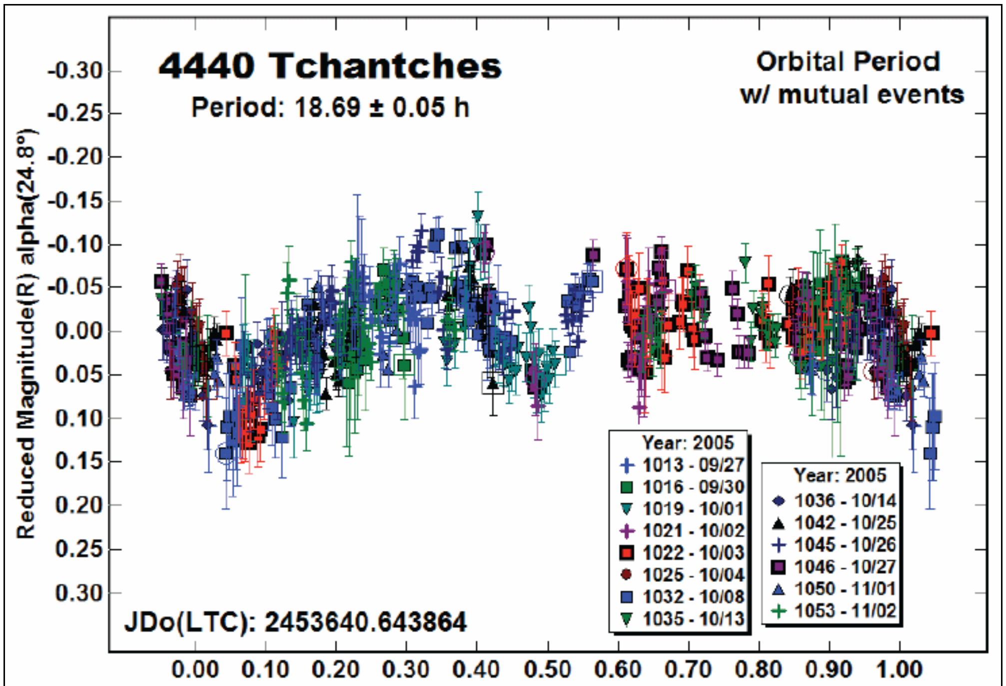

Figure 6. The lightcurve for 4440 Tchantches showing the effects of the satellite: an upward bowing indicating an elongated body and "dips" due to occultations and/or eclipses.

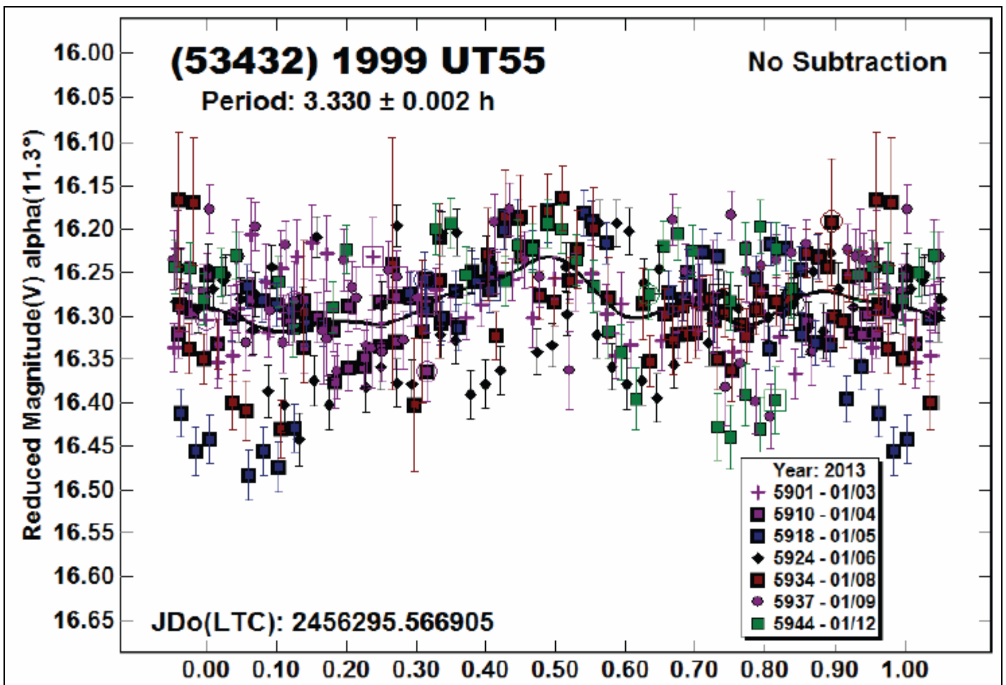

Figure 7. The unsubtracted lightcurve for (53432) 1999 UT55.

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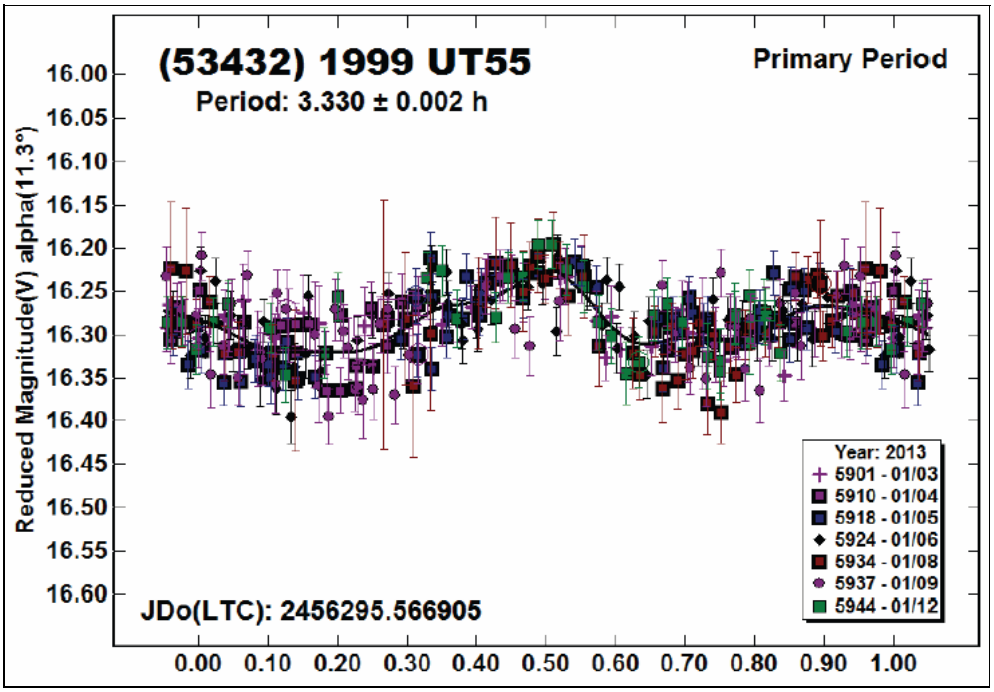

Figure 8. The lightcurve of (53432) 1999 UT55 showing the rotation of the primary.

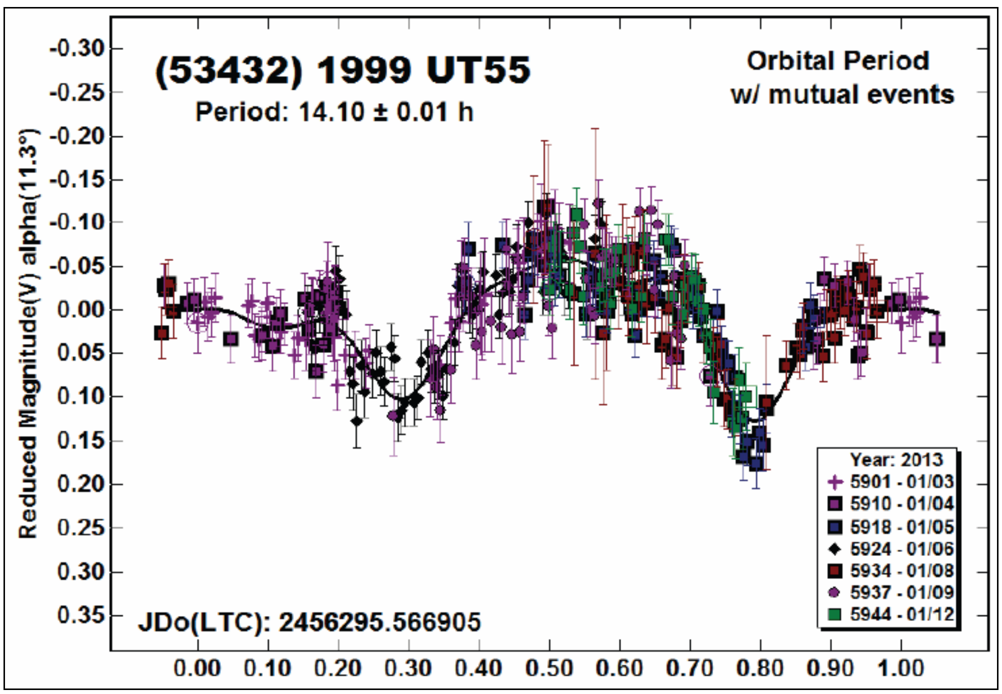

Figure 9. The lightcurve for (53432) 1999 UT55 showing mutual events due to the presumed satellite.