

Acknowledgments

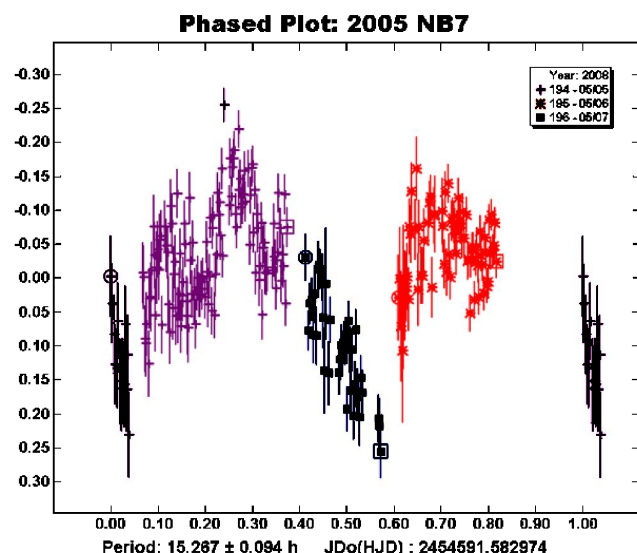
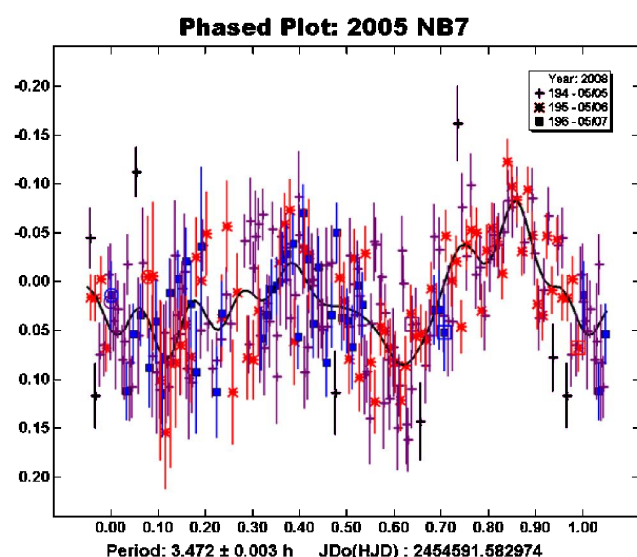
The author appreciates the help from Brian Warner in noting the binary nature of this asteroid, discovery references, and additional assistance.

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A STUDY OF THE TRINARY NEA 2001 SN263

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Projeto "Descobrimdo o Céu"

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The trinary NEA, 2001 SN263, was observed by the authors in 2008 February in Salvador, Bahia, Brazil. Based on the data obtained, the synodic period of the primary body was estimated to be 3.20 ± 0.01 h with a lightcurve amplitude of 0.27 ± 0.07 mag. The orbital period of the smaller satellite (0.4 Km) was estimated to be 46.1 ± 0.3 h. The NIR spectrum suggests the object is of type C according to DeMeo classification. Lance, a CO3 type meteorite, is the best analogous meteorite.

The near-Earth asteroid (NEA), (153591) 2001 SN263, which belongs to the Amor dynamic group, was observed by the Arecibo station during 16 days in 2008 February. These observations identified the asteroid as being a triple system. Preliminary data reductions suggest that the components have diameters of 2 km, 1 km, and 0.4 km. The orbit of the larger satellite has a semi-major axis > 15 km and orbital period of 15 days, while the orbit of the smaller satellite has a semi-major axis of ~ 4 km and orbital period of < 2 d. The larger satellite does not appear to be tidally-locked with its orbit. (Nolan *et al.* 2008).

Because of favorable viewing circumstances, this NEA was chosen to be observed by the "Discovering the Sky" project. Observations were carried out between 2008 February 8 and 11 UT in order to determine the synodic period of the primary. We used a 0.3-m Meade LX200 GPS telescope, operating at $f/3.3$, combined with a CCD SBIG ST-7XME. The 15-second exposures were through a clear filter and spaced at one-minute intervals. This resulted in an SNR of ~ 100 when using a photometric aperture of $\sim 1.5 \times$ FWHM of nearby non-saturated stars. All images were processed with bias, dark, and flat-field images. Period analysis was done on 280 data points using the Fourier analysis routines in *MPO Canopus* v9.3.0.1, which found a period of 3.20 ± 0.01 h and amplitude of 0.27 ± 0.07 mag (Fig 1). This compares with 3.4250 ± 0.002 h and 0.15 ± 0.02 mag (Higgins 2008) and 3.4251 ± 0.002 h and 0.10 ± 0.05 mag (Oey 2008). While all three are similar, they disagree significantly with the results published by Strajnik (2008) of 5.1900 ± 0.0002 h.

Two mutual events were seen in the observations on February 9 and 10 UT. They may be due to an eclipse of one of the satellites by the primary (Fig. 2) or the transit of a satellite across the primary body disc of the system 2001 SN263 (Fig. 3). The first event showed a drop of 0.63 ± 0.05 mag and duration of 20 min while the second ("transit") showed a drop of 0.92 ± 0.07 mag and duration of ~ 25 min. Each was similar to those observed in eclipsing double star systems in equivalents orbital phases (Hall, 2005). Assuming the two events were due to the

satellite, Fourier analysis found an orbital period of 46.1 ± 0.3 h (Fig. 4). This is in good agreement with the orbital period determined from the Arecibo data for the smaller (0.4 km) satellite and, therefore, the events are likely due to that object.

A near-Infrared spectrum of 2001 SN263 was obtained on 2007 December 15 by NASA Infrared Telescope Facility (IRTF) at Mauna Kea Observatory in Hawaii. NIR data were collected using SpecX medium-resolution spectrograph (Rayner et al., 2003). The asteroid spectrum covers ~ 0.75 – $2.55 \mu\text{m}$. These data were obtained within the context of “The MIT-UH-IRTF Joint Campaign for NEO Spectral Reconnaissance” of the Massachusetts Institute of Technology (MIT), the University of Hawaii and NASA IRTF, and are available at <http://smass.mit.edu/minus.html>.

The object spectrum (Fig. 5) presents an absorption feature near $0.9 \mu\text{m}$ that is offset from features caused by solid or liquid water and from telluric water vapor, as shown by the asteroid (253) Mathilde (Kelley et al. 2007). A morphological analysis suggests a neutral to slightly reddish and featureless spectrum for wavelengths $> 0.55 \mu\text{m}$ (Bus et al., 2002), similar to those presented by C type asteroids in different classical taxonomic systems such as Tholen (1984), Howell et al. (1994), and SMASS II (Bus & Binzel, 2002). For a wavelength $< 2.1 \mu\text{m}$, the spectrum presents a low albedo typically associated to primitive meteorites like carbonaceous chondrites. The lack of data in UBVR Johnson-Cousins filters meant we could not complete the available NIR spectrum and, so, the DeMeo taxonomic classification procedure (DeMeo, 2007) could not be applied in order to confirm the suggested C type classification for this object. Therefore, 2001 SN263 might belong to any subtype in DeMeo’s C asteroid class, which includes the C, Cb, Cg, Cgh, and Ch types.

The identification of a carbonaceous chondrite analogous meteorite in Gaffey’s collection (Gaffey, 2001) with a similar spectral curve to the asteroid was performed by calculating the value of the L1 norm, which was used due to its robustness. The search was carried out in the region of 0.805 – $1.005 \mu\text{m}$, which is centered in $\sim 0.9 \mu\text{m}$ absorption band. Limiting the search to this region is suggested by Gaffey et al. (2002) since adjustment between the spectra of the asteroid and meteorite is not always possible due to (1) the grains size, data collection geometry, and temperature of the sample or (2) the lack of spectral reflectance data on meteorites that were not affected by Earth-weathering. The best match between spectra came by using the one of the Lance meteorite (L1=1.09), see Fig 5. The second best fit occurred with a sample of the Felix meteorite (L1=1.14). Both samples belong to the CO3 type. It can be concluded after this part of the study that the surface of the asteroid 2001 SN263 is doubtless associated with carbonaceous chondrites meteorites.

Acknowledgments

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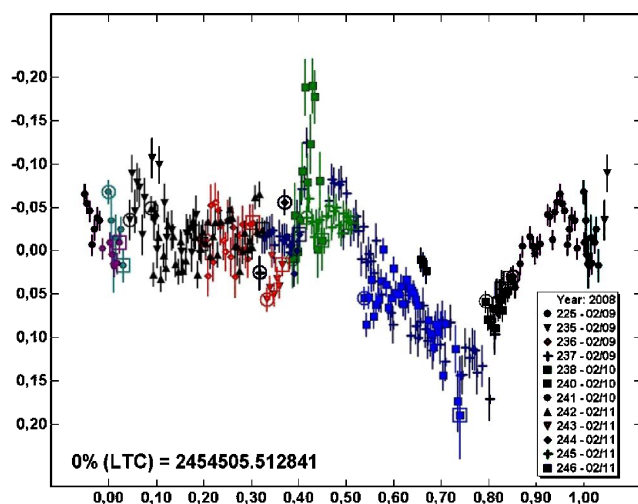


Fig. 1. 2001 SN263 lightcurve phased to 3.20 h. This curve does not include probable mutual events.

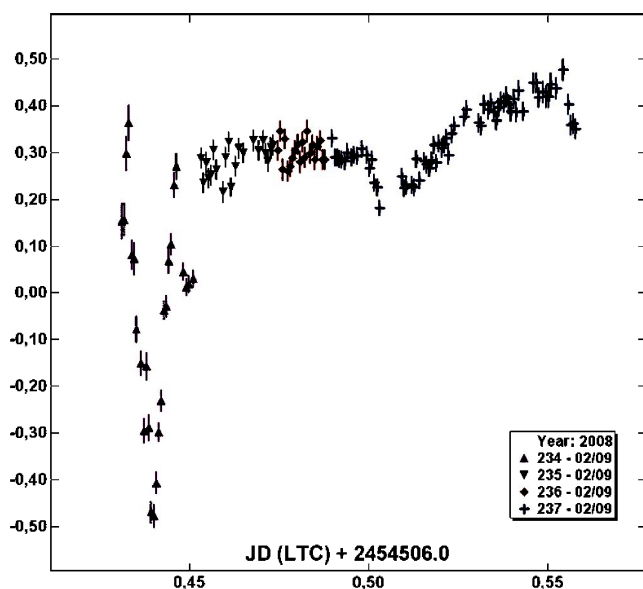


Fig. 2. Lightcurve of eclipse of the smaller satellite by primary.

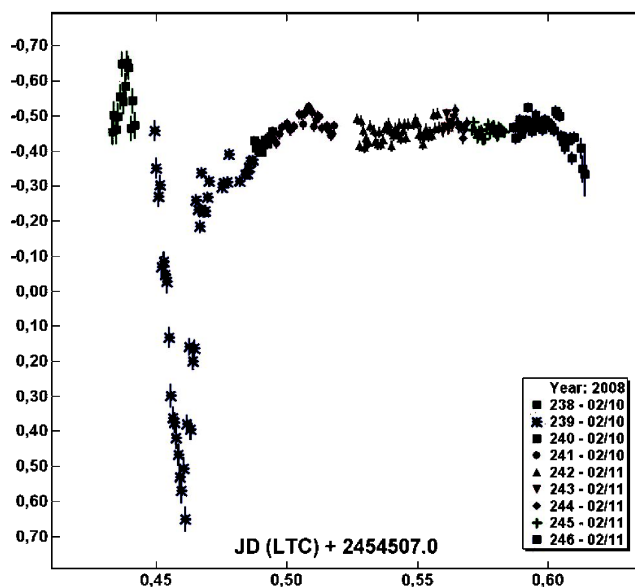


Fig. 3. Lightcurve of the smaller satellite transit over the primary.

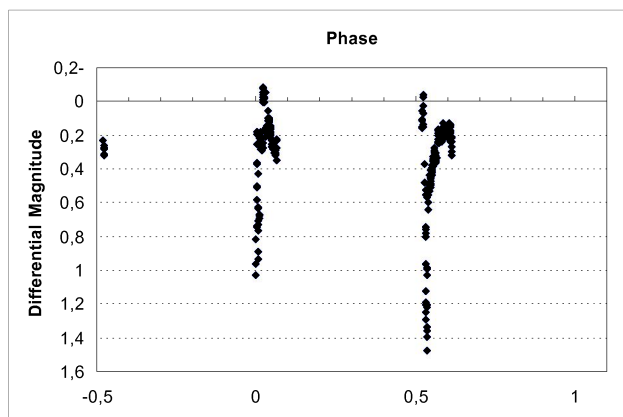


Fig. 4. Adjusted lightcurve of the orbital period of the smaller satellite, phased to 50.3 h.

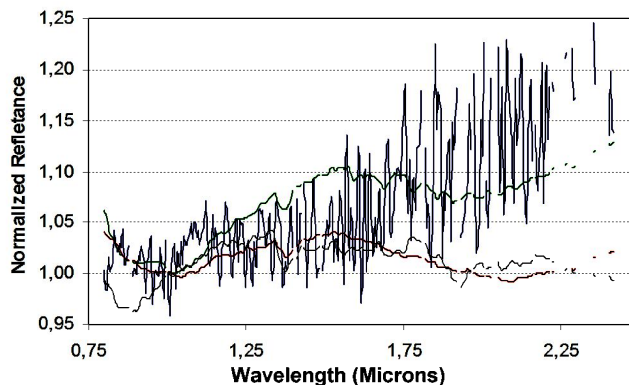


Fig. 5. 2001 SN263 NIR spectrum (blue) compared to the spectrum of the meteorites Lance (green), Felix (red), and Orgueil (black). The spectrum is normalized to the value at 1.0 μ m.