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Physical parameters of near-Earth asteroid 2017 VR12 from radar and optical photometric observations

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Abstract

We report results of bistatic radar and optical photometric observations of near-Earth Asteroid 2017 VR12. This asteroid closest approach was on March 7 at a distance of 0.0097 au. The continuous wave echo power spectra were obtained during March 5, 2018 using Goldstone radar to transmit and 32-m radio telescopes in Zelenchukskaya and Badary observatories to receive the echoes. Light curve data were made using 0.65 m telescope at the Ussuriysk Astrophysical Observatory on March 6, 2018. We find that the asteroid rotates with a period 1.378 $\pm$ 0.03 hours and have a pole-on silhouette breadth of 138 m. Our estimates of radar albedo are 0.32 $\pm$ 0.04 and 0.31 $\pm$ 0.04 and the circular polarization ratios are 0.36 $\pm$ 0.02 and 0.34 $\pm$ 0.01 for Zelenchukskaya and Badary correspondingly.

1. Introduction

Asteroid 2017 VR12 was discovered on November 10, 2017 by the 60-inch Pan-STARRS 1 telescope at Haleakala Observatory. 2017 VR12 is an Amor class near-Earth asteroid (NEA) with an orbital semi-major axis of 1.3696 au and a perihelion distance of 1.0004 au and is classified as a "Potentially Hazardous Asteroids" by the Minor Planet Center. On March 7, 2018 this asteroid approached the Earth within 0.0097 au which was the closest encounter since its discovery. Pravec et al. (http://www.asu.cas.cz/ ppravec) reported a light curve period of 1.37752 $\pm$ 0.00007 h with an amplitude of 0.2. However, the physical parameters of this asteroid were unknown except its absolute magnitude of 20.6 which, for mean optical albedo from 0.05 to 0.5 suggests a diameter from 450 to 140 meters.

In March 2018, we had the opportunity to conduct a bistatic radar observations of 2017 VR12 in cooperation with the Goldstone planetary radar and also obtain photometric observations from Ussuriysk Astrophysical Observatory. Here we present a physical parameters of 2017 VR12 derived from radar and light curve data.

2. Photometric observations

We observed 2017 VR12 at the Ussuriysk Astrophysical Observatory on March 6, 2018 with the 0.65 m telescope equipped with a KAF-4301E CCD. The observations began at 11:50:39 UT and covered 2.57 h during which 500 images of the asteroid were taken through a clear filter with an interval between frames and exposure time of 10 seconds and resolution of 3.8 arc seconds per pixel. The asteroid's magnitude was measured relative to 16 comparison stars from the UCAC4 catalog. Fig. 1 shows the light curve of the asteroid 2017 VR12 obtained as a result of observations. The average brightness of the asteroid was 11.8 magnitude and varied within 0.6 magnitude. One can see periodic variations in brightness including two maxima and two minima of different amplitudes, which can occur due to the precession of the rotation axis. Using a Fourier series method to the light curve data we obtained the most probable rotation period of 1.378 $\pm$ 0.03 h.

3. Radar observations

We observed 2017 VR12 on March 5, 2018 using 32-m radio telescopes in Zelenchukskaya and Badary observatories. Goldstone radar transmitted 150 kW circular polarized continuous wave (CW) signal at 8560 MHz (3.5 cm). Echoes were recorded simultaneously in the same (SC) and opposite (OC) senses of circular polarizations as the transmission. Taking into account the Doppler frequency as a function of time we applied the Fourier transform to the echo time se-

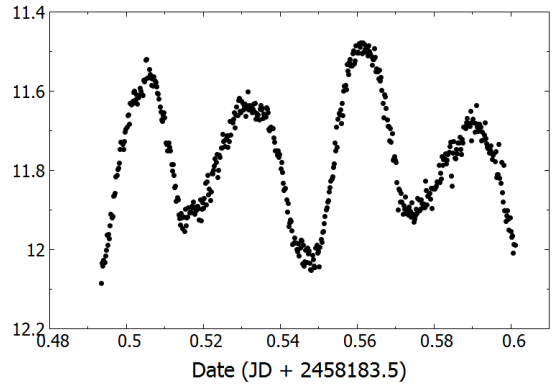
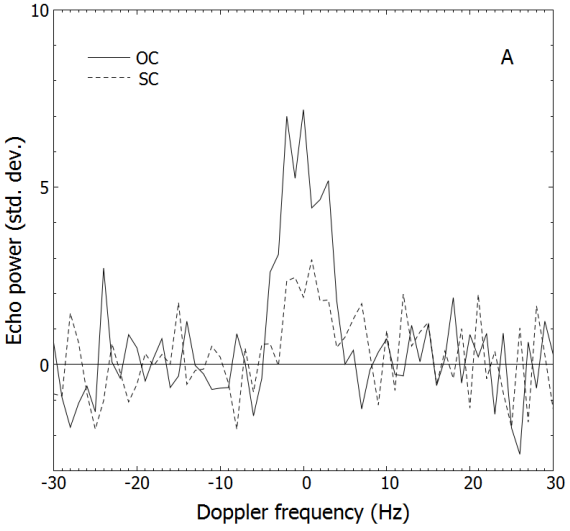


Figure 1: Lightcurve data of 2017 VR12 obtained at Ussuriysk Astrophysical Observatory on March 6, 2018.

ries. As a result we obtained CW echo power spectra for 9 minutes integration time with 1 Hz frequency resolution. At the Fig. 2 you may see the OC and SC continuous wave echo power spectra of 2017 VR12 obtained at Zelenchukskaya (A) and Badary (B) observatories. Echo power is plotted in standard deviations versus Doppler frequency relative to the estimated frequency of echoes from the asteroid's center of mass.



Knowing the rotation period and instantaneous echo power spectra bandwidth $\sim$10 Hz and assuming zero angle between the observer line-of-sight and the object's apparent equator we may estimate the lower bound on the asteroid's maximum pole-on breadth of

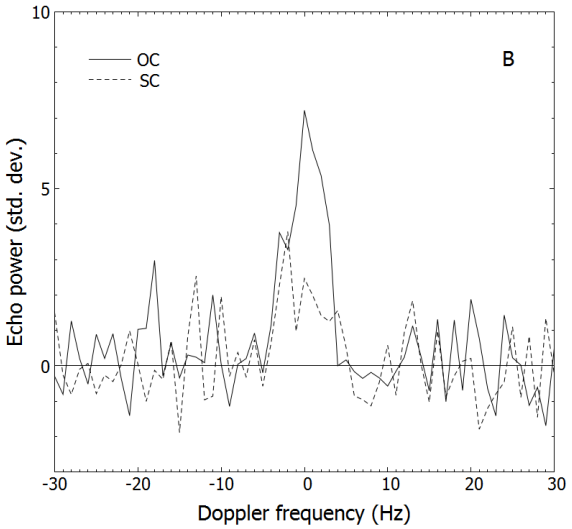


Figure 2: Continuous wave echo power spectra of 2017 VR12 obtained at Zelenchukskaya (A) and Badary (B) observatories on March 5, 2018 from 4:16 to 4:25 UT. Each curve has a frequency resolution of 1 Hz. Solid and dashed lines denote echo power in the OC and SC polarizations.

138 m at the rotation phase ϕ. By integrating the CW spectra we obtained the radar albedo of 0.32 $\pm$ 0.04 for Zelenchukskaya and 0.31 $\pm$ 0.04 for Badary suggests S or M-class NEA with a bright surface [1]. The ratio of the integrated SC and OC signal is a measure of near-surface wavelength-scale roughness. We estimated the circular polarization ratios of 0.36 $\pm$ 0.02 and 0.34 $\pm$ 0.01 for Zelenchukskaya and Badary correspondingly, indicates that the near-surface of 2017 VR12 at decimeter scales is morphologically rougher than those of most radar-detected NEA's [2].

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