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Radar observations and characterization of (436724) 2011 UW158

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Abstract

Near-Earth asteroid (436724) 2011 UW158 made a close approach to the Earth on 2015 July 19 at a distance of 0.016 au (6.4 lunar distances), which provided an outstanding opportunity for ground-based radar imaging. We observed it using the Goldstone X-band (8560 MHz, 3.5 cm) radar, the Green Bank Telescope (GBT), and Arecibo S-band (2380 MHz, 12.6 cm) radar, between July 13-26. The radar dataset allowed us to estimate the shape, spin state, and other physical properties of the object.

1. Introduction

(436724) 2011 UW158 is an Apollo asteroid with a semimajor axis of 1.6 au, a perihelion distance of 1.01 au, an eccentricity of 0.38, and an inclination of 4.6 degrees. It is classified as a potentially hazardous asteroid and has an absolute magnitude of 19.9. It is a spacecraft accessible target with a low delta-V and is on NASA's near-Earth object human accessible targets list. Lightcurves obtained shortly before the radar observations showed that the asteroid spins extraordinarily fast with a rotation period of 36.6 minutes [1], which was confirmed by the sequence of radar images. The lightcurves have an extremely high amplitude of about 2 magnitudes, suggesting a very elongated shape.

2. Radar imaging

Arecibo and Goldstone delay-Doppler observations achieved range resolutions as fine as 7.5 m (Figure 1), which revealed considerable detail. The highest resolution Goldstone transmissions were received at the GBT, which increased the signal-to-noise ratios (SNRs) two-fold relative to monostatic observations and allowed us to obtain images with range resolutions equal to those at Arecibo. The radar images reveal an elongated object with visible extents of about 600 x 300 m and an angular shape with a large facet on one side that spans the entire length of the asteroid. Three parallel radar-bright features are visible when the asteroid is oriented broadside to the radar line of sight and may represent ridges. These features cause unusually large brightness variations in the echo as the asteroid rotates. There are other small, radar-bright regions that look like the signatures of boulders. Repetition of the leading-edge profiles in the images indicates a spin period of 36.6 minutes that is consistent with the period that was previously reported using lightcurves [1]. This spin period is unusually fast among asteroids its size and suggests that 2011 UW158 has some cohesive strength.

3. Shape and spin state model

We used SHAPE [2][3] to fit a preliminary 3D shape model and spin state to two days of data spanning more than six full rotations of the asteroid. We did a grid search for the spin pole of the asteroid and Figure 2 shows the goodness of fit for spherical harmonics models with different spin pole orientations. We were able to constrain the spin pole to one region centered on ecliptic longitude and latitude of 190, -45 degrees.

Figure 3 shows the preliminary best fit shape model using the nominal spin pole. The model has an effective resolution of about 30 m and has dynamically equivalent equal volume extents (DEEVE) of 550 x 280 x 275 m. This preliminary model captures the overall shape very well but doesn't yet reproduce all the parallel radar-bright

features that are conspicuous in the images (Figure 4). We anticipate further improvements to the model and the spin vector estimate.

4. Figures

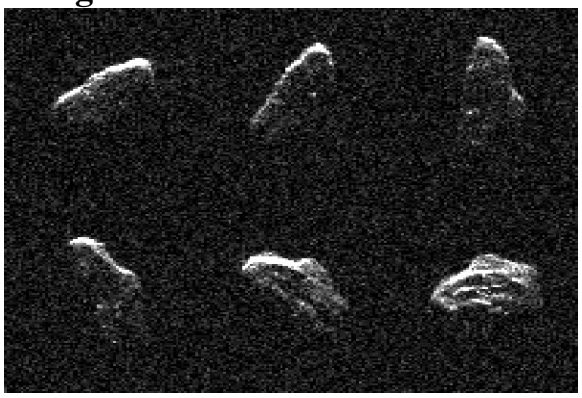

Figure 1: Bistatic Goldstone-GBT radar images of 2011 UW158 obtained on July 18, 2015. Image resolution is 7.5 m x 0.5 Hz.

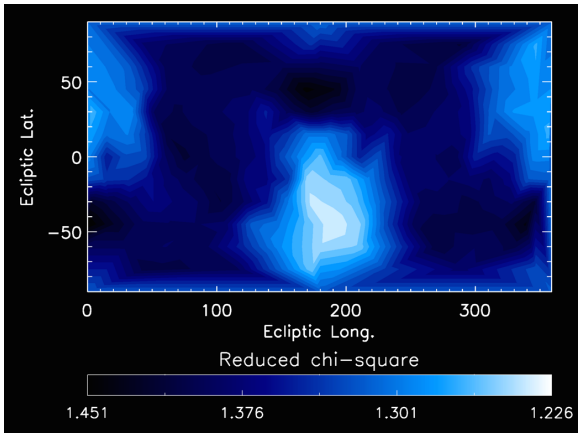

Figure 2: Contour plot of the goodness of fits (χ^2) of shape models having different spin axis orientations. Lighter colors indicate better fits. Best-fit spin axis is at ecliptic longitude and latitude of (190, -45) degrees.

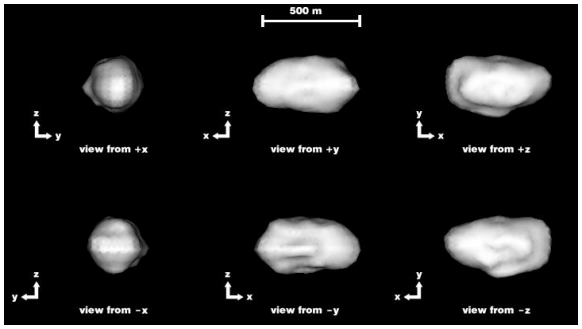

Figure 3: Principal axis views of the preliminary primary shape model. The shape model has 1000 vertices and 1996 triangular facets. The effective resolution of the model is ~ 30 m.

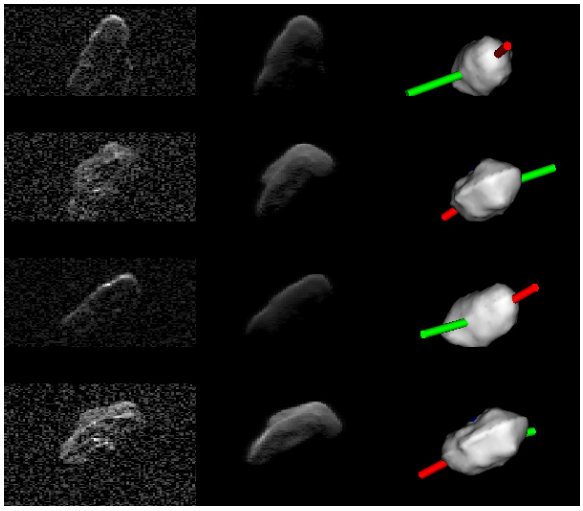

Figure 4: Preliminary Shape model fits to selected Arecibo radar images. Each row shows the observed image (left), a synthetic image generated from the shape model (center), and the corresponding plane-of-sky (POS) view of the model.

References

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