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Binary Near-Earth Asteroid 2000 DP107: Component Shapes, Mutual Orbit, and Evolution

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1. Introduction

2000 DP107 was the first Near Earth Asteroid (NEA) binary ever imaged [1]. During its 2008 return, the radar signal-to-noise ratio was 20 times higher than in 2000, which provided an opportunity to obtain very detailed images with range resolution as fine as 30 m. The 2008 observability window spanned 16 days, allowing for excellent rotational and aspect angle coverage, an ideal situation for shape modeling and binary orbit fitting. The data quality enables a precise determination of the reflex motion and component mass ratio, as well as shape modeling of both components.

2000 DP107 is a low delta-v object and so it is a favorable target for spacecraft rendezvous and sample return missions.

2. Science objectives

The goals of our 2008 observations were multiple: image surface features; obtain component shapes, volumes, masses, densities; measure librations of the secondary; and quantify the orbital evolution between the 2000 and 2008 encounters. 2000 DP107 is a prime target for BYORP detection due to its frequent apparitions. Our radar data can provide the detailed shape models and orbital parameters that are essential to properly model the evolution of the mutual orbit under the influence of tides and BYORP.

3. Observations

2000 DP107 made a close approach on 2008 Sep 11 when it was within 0.058 AU of the Earth. Doppler spectra and imaging data were obtained from 2008 Sep 9 to Sep 24 using the Arecibo S-band (2380-MHz, 13-cm) and Goldstone X-band (8560-MHz, 3.5-cm) radar systems. Overall 180 delay-Doppler images and 94 Doppler spectra spanning 7 days were used for shape modeling.

4. Shape Modeling

Shape modeling for the two components was performed with the SHAPE software [2, 3] which uses a constrained-least-squares algorithm for fitting a shape to the data. We assumed that the secondary orbits in the equatorial plane of the primary, which is consistent with the formation by spin-up [1], and we used the orbit pole as an initial estimate for the spin pole of the primary. Other spin poles were explored, but did not yield better fits. We proceeded from ellipsoidal models to spherical harmonic models and then to vertex models. The current model uses 500 vertices (996 facets), yielding an effective surface resolution of $\sim$75 m.

5. Results

The shape model of the primary reveals a top-shaped object with an equatorial ridge similar to that of the 1999 KW4 primary [4]. The primary has a dynamically equivalent equal-volume ellipsoid (DEEVE) average diameter of $\sim$850 m and the secondary has a DEEVE average diameter of $\sim$290 m which is in agreement with previous estimates [1]. The equatorial ridge on the primary shows two concavities of $\sim$350 m and $\sim$200 m. Figure 1 shows a comparison of a number of observed images spanning four days with synthetic images generated by SHAPE. The secondary is rotating synchronously but may exhibit librations that we are in the process of quantifying. Librations may have a profound influence on the coupled spin-orbit evolution of the system [5, 6]. Our data set will allow us to measure the secondary elongation and to test dynamical models of librations and orbital evolution.

The 2008 data also allow for an independent and improved determination of the binary orbit that we can compare to earlier results [1, 7] to quantify orbital evolution. Updated estimates of orbital parameters, component shapes and masses, and libration amplitude will be presented at the meeting.

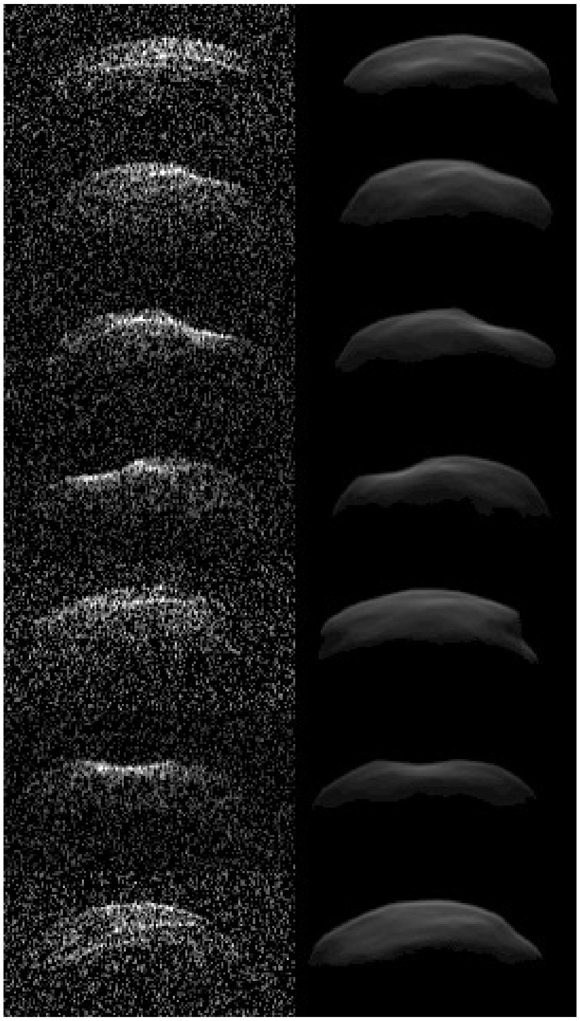

Figure 1: Images of the 2000 DP107 primary at 30 m resolution (left) and synthetic images derived from shape model (right).

Acknowledgments

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