Shape and spin state modeling of binary near-Earth asteroid 65803 Didymos

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Binary near-Earth asteroid 65803 Didymos is the target of the proposed Asteroid Impact and Deflection Assessment (AIDA) space mission. The mission consists of two spacecraft, the Demonstration for Autonomous Rendezvous Technology (DART) spacecraft that will impact the asteroid's satellite and the Asteroid Impact Mission (AIM) spacecraft that will observe the impact. We used radar observations obtained at Arecibo and Goldstone in 2003, and lightcurve data from Pravec et al. (2006) to model the shapes, sizes, and spin states of the components. The primary is top shaped and has an equatorial ridge similar to the one seen on 2000 DP107 (Naidu et al. 2015). A 300 m long flat region is also seen along the equator. The primary has an equivalent diameter of 780 m (+/- 10 %) and its extents along the principal axes are 826 m, 813 m, and 786 m (10% uncertainties). It has a spin period of 2.2600 +/- 0.0001 h. A grid search for the spin pole resulted in the best fit at ecliptic (longitude, latitude) = (296, +71) degrees (+/- 15 degrees). This estimate is consistent with the spin pole being aligned to the binary orbit normal at (310, -84) degrees. Dividing the primary mass of 5.24e11 kg (Fang Margot 2012) by the model volume we estimate a bulk density of 2100 kg m-3 (+/- 30 %). We summed multiple radar runs to estimate the range and Doppler extents of the satellite. We estimated the motion in successive images and used a shift-and-sum technique to mitigate smearing due to translational motion. This boosted the SNRs and allowed us to obtain size and bandwidth estimates of the satellite. The visible range extent of the satellite is roughly 60-75 m at the 15 m resolution of the Arecibo images. Assuming that the true extent is twice the visible extent, we obtain a diameter estimate of 120-150 m. The bandwidth of the satellite suggests a spin period between 9-12 h that is consistent with the orbit period of 11.9 hours and with synchronous rotation.