THE SHAPE, MUTUAL ORBIT, AND TIDAL EVOLUTION OF BINARY NEAR-EARTH ASTEROID 2004 DC. P. A. Taylor[1], J. L. Margot[1], M. C. Nolan[2], L. A. M. Benner[3], S. J. Ostro[3], J. D. Giorgini[3], and C. Magri[4], [1]Department of Astronomy, Cornell University, Ithaca, NY 14853 (ptaylor@astro.cornell.edu), [2]Arecibo Observatory, [3]Jet Propulsion Laboratory, [4]University of Maine at Farmington.

Introduction: Radar observations show near-Earth asteroid 2004 DC is a binary system with an eccentric mutual orbit, an asynchronously rotating secondary, and a primary having a shape reminiscent of 1999 KW_4. The lack of a tidally circularized orbit and synchronized secondary may imply 2004 DC is a young or recently excited binary system.

Observations: Arecibo S-band (2380 MHz, 13 cm) and Goldstone X-band (8560 MHz, 3.5 cm) radar observations from June 2-6, 2006 showed that 2004 DC is a binary system with a size ratio of roughly 5:1 [1] and witnessed a mutual event where the secondary passed through the radar shadow of the primary. A combination of high resolution images, as fine as 7.5 m in range, and long observing windows provided by Arecibo and Goldstone allow us to produce a detailed shape model of the primary and determine the mutual orbit of the components about the system's center of mass.

Results: Preliminary shape modeling suggests a shape for the primary similar to 1999 KW4 [2] including a pronounced circular equatorial belt, sloped sides, and flattened poles. Such a shape could be indicative of a binary formation process that spins up the primary, redistributes regolith to the equator, and causes material to be shed into orbit about the primary.

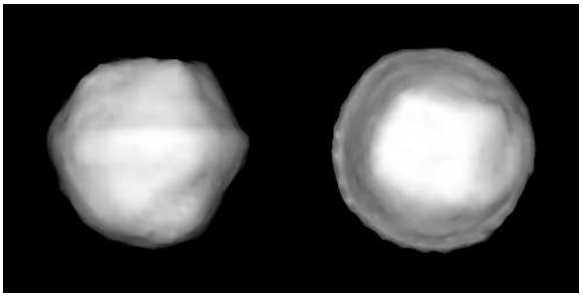

Figure 1. Equatorial and polar views of the preliminary shape model for binary near-Earth asteroid 2004 DC's primary component. Note the ∼360-m diameter circular belt at the equator and flattened poles similar to 1999 KW_4.

The mutual orbit of 2004 DC has a semimajor axis of 4.4 primary radii and has an eccentricity of 0.24, which is atypical of near-Earth binary asteroids. The rotation period of the secondary also appears to be unsynchronized to its orbital period, 7 h versus 23 h, respectively. Considering most binary systems have tidally synchronized secondaries and tidally circularized mutual orbits, 2004 DC either is a comparatively young binary system, was recently excited by a close planetary encounter, or is in a dynamical state that allows for an eccentric, asynchronous secondary during tidal evolution.

Although the precise rotation pole for the primary is undetermined, the best pole solutions from the observed radar bandwidths of the primary are in good agreement with the best fit orbit normals for the secondary, suggesting an equatorial orbit. The 2.6-h lightcurve period of the primary [3] and the total angular momentum of the system suggest possible formation of the binary system through a spin-up mechanism such as the YORP effect [4] or close planetary tidal encounter [5].

Discussion: The observation of a 1999 KW_4-shaped asteroid leads one to question whether all primary components in binary systems presumably formed via a spin-up mechanism have the same characteristic shape that includes a circular equatorial ridge, sloped sides, and flattened poles. Opportunities to study known binaries 2000 DP_{107} [6] and 1991 VH [7] in the summer of 2008 at a level comparable to the 1999 KW4 dataset will help determine if this shape is characteristic of primaries in the near-Earth region. We are also investigating the effects of tidal evolution on the eccentricity of the mutual orbit to determine if an eccentric orbit necessarily indicates youth or if an eccentric mutual orbit is a natural state under certain dynamical conditions.

References: [1] Taylor, P.A., *et al.* (2006) *AAS/DPS 38*, Abstract #50.04. [2] Ostro, S.J., *et al.* (2006) *Science*, *314*, 1276-1280. [3] Behrend, R., (2006) http://obswww.unige.ch/∼behrend/page5cou.html#04d00c. [4] Bottke, W.F., *et al.* (2002) in *Asteroids III*, 395-408. [5] Richardson, D.C., *et al.* (1998) *Icarus*, *134*, 47-76. [6] Margot, J.L., *et al.* (2002) *Science*, *296*, 1445-1448. [7] Pravec, P., *et al.* (2006) *Icarus*, *181*, 63-93.