RADAR DERIVED SHAPE MODEL OF BINARY NEAR-EARTH ASTEROID (285263) 1998 QE2

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We report progress on a shape model of binary near-Earth asteroid system 1998 QE2 derived from radar data taken during its May 2013 close approach to Earth [1] as well as subsequent days in June 2013. Roughly 16% of NEAs are binary systems [2, 3], allowing us to determine the density of the primary. The secondary moons shape is resolved in radar data and its rotation appears to be tidally locked with the primary.

Preliminary results indicate that 1998 QE2 is dark, cratered body approximately 3 km in diameter with a spin period of 4.75 $\pm$ 0.01 h (P. Pravec, personal communication). The primary shows minor topography with no obvious boulders, and the equator deviates somewhat from circular (Fig. 1). If the primary has a spherical shape, it has a density of $\rho \approx 0.75$ g/cm^3; while for a 1999 KW4-like shape, $\rho \approx 1.0$ g/cm^3.

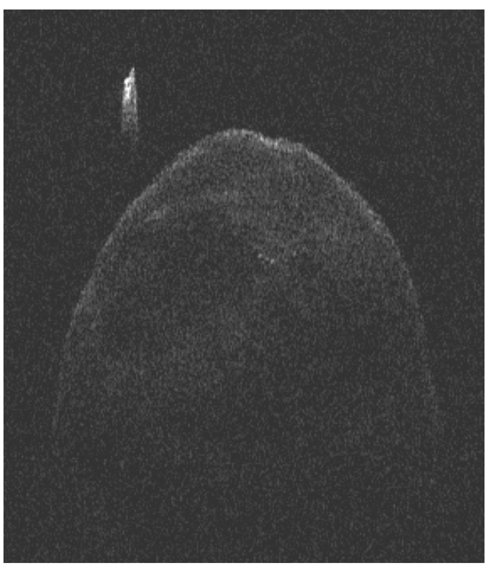

Figure 1: Arecibo radar data of 1998 QE2 taken on June 7. The secondary appears as a bright streak to the upper left of the asteroid. The primary is 3 km across and the image resolution is 7.5 m/pixel along the vertical axis. The image is a sum of three runs taken 10 minutes apart.

The rotation of the secondary is consistent with being tidally locked, and radar data show a non-spherical shape with a indention near one end (Fig. 2). The size ratio of the primary to the secondary is $\approx$ 4:1, with the secondary being approximately 750 m in size. The primary and secondary are in a circular mutual orbit, with a period of 1.3045 ± 0.001 days. The semi-major axis is 6.212 ± 0.1 km, approximately four times the radius of the primary, with an eccentricity $e < 0.01$. This orbit is typical for binary NEAs.

The mutual orbit plane is consistent with the equator plane of the primary or the mutual orbit normal is roughly parallel to the spin axis of the primary. The primary's rotation appears prograde from fits to a subset of radar data. The orbit of the secondary is consistent with being low inclination and equatorial, but the system's rotational axis is not aligned with its heliocentric orbit normal. It is likely that YORP has not pushed the system to the typical endpoints of 0 or 180 degrees obliquity.

Figure 2: Arecibo radar data of the 1998 QE2 secondary showing an indentation on June 7. The dent moves from close to horizontal to more canted as it approaches equal distance, indicating that the dent must be toward the end and not the middle of the wedge-shaped secondary. The secondary is 750 m across.

We observed 1998 QE2 in the infrared (0.8-4 μm) at the NASA IRTF on five dates between 30 May and 10 July 2013. The reflected spectrum is featureless and red-sloped, similar to outer-belt asteroids, perhaps with organic-rich material on the surface. The thermal emission is very strong at wavelengths beyond 2.3 microns,

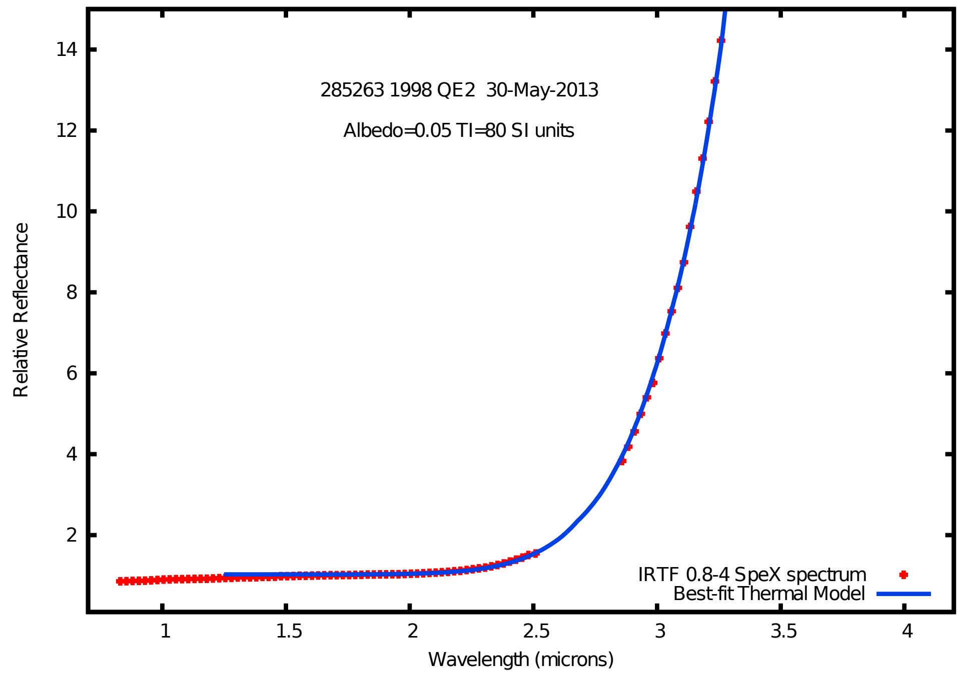

Figure 3: NASA IRTF infrared observations of 1998 QE2 on May 30, 2013, showing a featureless, red-sloped spectrum.

indicating a low albedo. The best-fit simple thermal model suggests an visible albedo of 0.05 ± 0.03, and a plot of the model on the observed combined spectrum is shown in Fig. 3. This model assumes a spherical shape and an equatorial view. Although this model fits these data well, the same thermal parameters do not match spectra on the dates in June and July, suggesting that the correct viewing geometry needs to be included. The dark red featureless spectrum does not match any meteorites well. Once the shape model is better determined, the thermal parameters can then be better constrained as well.

We use a non-linear, iterative inversion process for modeling the shape of both the QE2 primary and secondary called `shape`. Details of the inversion method are available in Magri et al. [4], based on the method of Hudson [5]. A model derived from radar data will be presented, to help further constrain system geometry and dynamics.

References

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