

## Shape model of the binary near-Earth asteroid (285263) 1998 QE<sub>2</sub>

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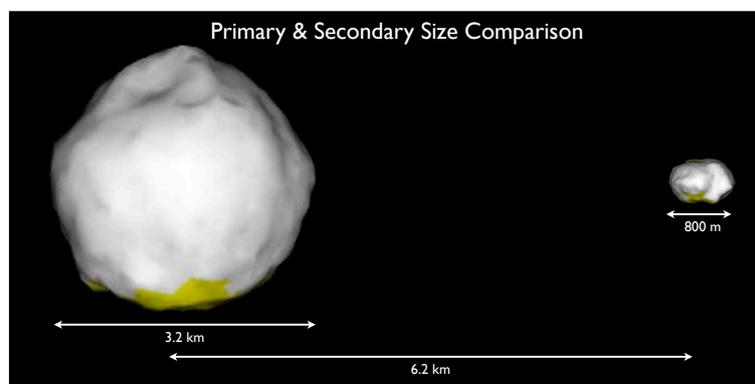
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Binary systems comprise  $\sim 1/6$  of the near-Earth object population larger than 200 meters in diameter, providing important clues to asteroids' masses and densities. On May 31, 2013, the binary near-Earth-asteroid system (285263) 1998 QE<sub>2</sub> had a 0.04-au close approach to the Earth. We observed the binary system from May 30 to June 27 with the Goldstone Solar System Radar (which discovered the system's binary nature, operating at 3.5 cm / 8.56 GHz) and Arecibo Observatory planetary radar system (operating at 12.6 cm / 2.38 GHz). The size of the QE<sub>2</sub> primary and the short light travel time afforded us an excellent data set of high resolution delay-Doppler images as fine as 7.5 meters/pixel of this asteroid and its moon. We used the extensive radar dataset to fit 3D shape models for both primary and secondary using a nonlinear iterative inverse process [1,2]. A preliminary scale model for both system components is shown in the figure. The preliminary primary model is a roughly spherical body,  $3.2 \pm 0.3$  km in effective diameter. Some radar-bright spots in the delay-Doppler images may be indicative of boulders. Lightcurve data show a rotation period of  $4.749 \pm 0.002$  h for the primary [3]. The best fit to a subset of radar data suggests a prograde pole at  $(119^\circ, +35^\circ)$  in ecliptic coordinates [4]. The secondary model indicates an effective diameter of  $800 \pm 80$  m (for a primary:secondary diameter ratio of  $\approx 4:1$ ) for an elongated object with a concavity on one side of the long axis. The secondary is in a tidally locked spin state with an orbital period of  $31.31 \pm 0.01$  h hours derived from radar, and a semimajor orbital axis of  $6.2 \pm 0.1$  km (approximately quadruple the radius of the primary). The orbit is approximately circular ( $e < 0.01$ ), which is typical of most near-Earth-asteroid binary-system orbits. We assume that the primary and secondary poles are aligned with the best-fit mutual-orbit pole. All orbital parameters were derived from radar data. From orbital fits, we estimate the system mass to be  $1.1 \pm 0.1 \times 10^{13}$  kg, giving a preliminary density for the primary of  $0.7 \pm 0.2$  g/cm<sup>3</sup>. The low density implies a high porosity for the primary consistent with a gravitational aggregate or "rubble-pile" structure. We will continue to refine the shape models for both the primary and the secondary to further investigate both the physical properties and dynamics of the 1998 QE<sub>2</sub> system.



**Figure:** 1998 QE<sub>2</sub> primary and secondary preliminary models to scale. Yellow regions on both models indicate regions only seen at grazing incidence with radar. Both primary and secondary models have 1148 vertices, or  $6^\circ$  resolution — 170-m resolution for the primary; 40-m resolution for the secondary.

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**References:** [1] Magri, C., et al. (2007) *Icarus*, 186, 152–177. [2] Hudson, S. (1993) *Remote Sensing Reviews*, 8, 195–203. [3] Pravec, P. (2013) Personal communication. [4] Springmann, A. et al. (2014) LPSC abstracts, 45, 1313.