RADAR AND OPTICAL OBSERVATIONS OF EQUAL-MASS BINARY NEAR-EARTH ASTEROID (190166) 2005 UP156. P. A. Taylor[1], E. G. Rivera-Valentín[1], A. K. Virkki[2], B. D. Warner[3], A. Aznar[4], F.C.F. Venditti[2], S. E. Marshall[2], L. F. Zambrano-Marin[2], B. Aponte-Hernandez[1], S. S. Bhiravarasu[1], and C. Rodriguez Sanchez-Vahamonde[5], [1]Lunar and Planetary Institute, Universities Space Research Association, 3600 Bay Area Blvd., Houston, TX 77058, USA (ptaylor@usra.edu), [2]Arecibo Observatory, University of Central Florida, [3]Center for Solar System Studies, MoreData!, [4]Observatorio Isaac Aznar, [5]University of Western Ontario.

Introduction: To date, only four equal-mass binary asteroids have been discovered among the near-Earth population: (69230) Hermes, 1994 CJ1, (190166) 2005 UP156, and 2017 YE5, all of which have been characterized with radar and optical lightcurves. Equal-mass binaries are relatively rare, making up less than 1% of radar-observed near-Earth objects larger than 200 meters in diameter, compared to ~15% for binaries with more disparate sizes and ~15% for bilobate (peanut-shaped) asteroids. Here, we report on modeling of the 2005 UP156 system.

Observations: Radar and optical lightcurve observations of binary asteroids are very complementary. Optical observations precisely constrain the spin states of the components and the mutual-orbital period, while radar observations precisely constrain the sizes, shapes, and scale of the mutual orbit. Whenever possible, radar and optical observations are combined to better understand the physical and dynamical characteristics of multiple-asteroid systems.

The binary nature of near-Earth asteroid 2005 UP156 was shown by distinctive mutual events in its optical lightcurves [1] from 2017 May 4 through June 12. The observed lightcurve period of 40.542 +/- 0.008 h agrees with the period determined in 2014 [2], though no mutual events were noted at that time. An out-of-eclipse lightcurve amplitude of 0.5 mag suggests the components have significant elongations. Radar observations with the Arecibo S-band (12.6 cm) planetary radar system (Fig. 1) on 15 dates from 2017 June 2 to July 10, when 2005 UP156 was 0.13 to 0.19 au from Earth, unambiguously revealed the nearly equal-size components of the binary system.

Results: Modeling of the shapes, spin states, and mutual orbit of the 2005 UP156 system is underway and a progress report will be presented. Preliminary size estimates from radar images are 900 meters in the longest dimension for both components. Images at different orientations confirm their elongated shapes, as expected from the out-of-eclipse lightcurve variations, with the long axes aligned, i.e., face-locked synchronous rotation, and an orbital period commensurate with the optical lightcurve period. The elongations of the shapes suggest equatorial axis ratios of about 1.5 to 1 for both components making these objects possibly the most elongated near-Earth asteroids known to have a satellite. Based on these ellipsoidal shapes, the absolute magnitude of 17.2 implies a bright optical albedo of roughly 30%.

The maximum observed separation between the components of 2.4 km is a lower limit on the semimajor axis of the system, though the projection effect should be minimal given the eclipsing nature of the contemporaneous lightcurves; the true semimajor axis is likely about 2.7 km. Combined with the size and shape estimates, the implied density of the system is 1.6 g/cm^3. Additionally, the total angular momentum of the system is some 50% more than that required for a sphere to shed mass, a value common to binary asteroids with disparate masses. Clearly, a significant source of angular momentum is required to form and maintain such a system.

Figure 1. Arecibo range-Doppler images of 2005 UP156 from 2017 July 7, July 5, and June 18, each with 75-m resolution, show the two nearly equal-size, elongated components with their long axes pointed toward each other.

References: [1] Warner, B. D. and A. W. Harris (2017) *CBET* 4394. [2] Warner, B. D. (2015) *Minor Planet Bulletin, 40*, 41-53.

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