The Shape and Spin Distributions of Near-Earth Asteroids Observed with the Arecibo Radar System

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Introduction: We investigate the shapes and spins of near-Earth asteroids observed with the Arecibo S-band (2380 MHz) radar system to understand how asteroids form and evolve. Radar is one of the few ground-based techniques that reveals overall shape and surface details, doing so with range resolution as fine as 7.5 m using Arecibo, which is comparable to the resolution attained by a spacecraft flyby. With such resolution, one can discern whether an asteroid is a single body, a double-lobed contact binary, or a multiple-asteroid system in mere minutes of observation. Radar observations also resolve the target in Doppler frequency, where the observed echo bandwidth is directly related to the spin rate and size of the asteroid, allowing one to immediately discern whether the rotation of the target is fast or slow.

Previous Results: Radar observations of near-Earth asteroids have revealed a heterogeneous population with diameters spanning meter to kilometer scales, diverse shapes ranging from simple spheroids to extremely irregular bodies (see Fig. 1), and rotation periods stretching from minutes to weeks. Since 1998, when the radar system was upgraded to transmit up to 1 MW, over 300 near-Earth asteroids have been observed with Arecibo. Thane et al. [1] examined those asteroids observed through 2010 that were well resolved at high power (above 600 kW output) and observed on multiple days allowing for unambiguous basic shape determination and found that the population was rather evenly distributed among spheroids, elongated bars, double-lobed contact binaries, multiple-asteroid systems, and irregularly shaped asteroids. This seems to imply that there is no dominant process of near-Earth asteroid evolution funneling the population to a general shape. Thane et al. [1] also found no clear correlation between shape and absolute H-magnitude, though the smaller end of the near-Earth asteroid population with $H > 23$ is not well sampled by radar.

Results: We will expand the Thane et al. [1] near-Earth asteroid shape distribution to include objects observed from 2011–2012. We will also determine the spin distribution of near-Earth asteroids, using the echo bandwidths and size estimates gleaned from radar observations to place upper limits on the spin periods of the bodies (allowing for comparisons to lightcurve-derived periods where available) and examine possible correlations between sizes, shapes, and spins.

Figure 1: Representative Arecibo radar images of each shape category, from left to right: spheroidal (308635) 2005 YU_{55} (see [2] this meeting), elongated (162421) 2000 ET_{70}, contact binary 2002 NY_{40}, binary system (175706) 1996 FG_3 (see [3] this meeting), and irregular (53319) 1999 JM_8 (see [4] this meeting), with diameters ranging from 360 meters to 7 kilometers and spin periods ranging from 3.6 hours to one week.

References

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