Radar observations and population trends of binary near-Earth asteroids

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The Arecibo and Goldstone planetary radars are invaluable instruments for the discovery and characterization of binary and triple asteroids in the near-Earth asteroid (NEA) population. To date, 41 out of 56 known binaries and triples (73% of the objects) have been discovered by radar. Furthermore, 49 of these multiple systems have been detected by radar. Their absolute magnitudes range from 12.4 for (1866) Sisyphus to 22.6 for 2015 TD144 and have a mean and rms dispersion of 18.1+-2.0. There is a pronounced decrease in abundance of binaries for absolute magnitudes H>20. Among 366 NEAs with H<22 (corresponding to diameters larger than 200 m) detected by radar since 1999, 13% have at least one companion. NEA binary systems are known among the S, Q, V, B, C, and P spectral classes, but not among the NEAs that have been classified as E- or M-types. The first well-studied binary system was (66391) 1999 KW4 (Ostro et al., 2006). The primary showed evidence for a prominent equatorial bulge, sloped hemispheres, and flat polar regions, shape attributes that have since been found on the primaries of numerous other NEA binaries. Additional evidence that the KW4-like shapes are real and not artifacts of the shape modeling occurred with Goldstone observations of 2013 WT44. 2013 WT44 was imaged at nearly pole-on subradar latitudes and the delay-Doppler images clearly show the signature of an equatorial bulge, sloped hemispheres, and polar flattening. We estimate the abundance of KW4-like primaries to be at least 40% based on the 49 radar-detected multiple systems. At least 10% of the primaries do not have KW4-like shapes. For example, the primaries of (276049) 2002 CE26 (Shepard et al., 2006) and (285263) 1998 QE2 (Springmann et al., 2014) have rounded shapes, with no obvious equatorial ridges, and the primaries of (164121) 2003 YT1, (1862) Apollo, and (363599) 2006 VV2 have irregular, moderately elongated shapes that show the presence of a bulge at only selected longitudes.