THE HETEROGENEOUS POPULATION OF NEAR-EARTH ASTEROIDS REVEALED BY THE ARECIBO PLANETARY RADAR. M. C. Nolan[1] and the Planetary Radar Team, [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721 (nolan@lpl.arizona.edu).

Introduction: In 1998, when the Arecibo Planetary Radar System came online after a major upgrade to the Arecibo 305m telescope, most asteroids, and in particular near-Earth asteroids, were believed to be collisional remnants of larger objects, but little else was known about them. A few had known compositions from Vis/IR optical observations, and a small handful had been visited by spacecraft. These objects were all "space potatoes": more-or-less irregular objects that could reasonably be collisional fragments of parent bodies in the asteroid belt. In the intervening decades, we have learned that the asteroid population, and in particular the near-Earth asteroid population, is quite heterogeneous, with a large variety of physical and chemical properties. The main contributors to this understanding were the large increase in objects discovered by the asteroids search programs and the imaging of objects with the Arecibo and Goldstone Radar Systems [1]. These two systems were largely complementary, with Arecibo providing much higher sensitivity, while Goldstone provides better sky coverage, longer observation windows, and higher peak resolution for the brightest targets.

What we measure: Radar directly measures distance (by measuring the time required for a radio signal to travel to the target and back) and speed (via Doppler shifting the frequency of a transmitted signal). With care and sufficient SNR, it is possible to separately determine the distance and speed of different points on a target, forming a two-dimensional image of an object that is much smaller than the optical diffraction limit. As a result, we have "spacecraft-flyby-quality" images of hundreds of objects, obtained at much lower cost than spacecraft observations. Radar observations often provide useful shape information in a short interval – one or a few days of observations, which is particularly important for near-Earth asteroids, which are often only visible for a short interval.

Sizes, Shapes, and Rotation Rates: Radar imaging provides a measure of the shape and size of an asteroid (by direct measurement of the range depth of the visible surface), and separately, a measure of the rotation rate of an object given its size. The observable quantity is the rotation velocity projected onto the line of sight, and thus an upper limit on the spin period. Approximately 1/3 of observed near-Earth objects are roughly spheroidal, and approximately half of those objects are multiple (binary [2] or ternary [3]) systems. No correlation has been seen with Vis/IR spectral types and asteroid shapes. The observed shapes span a wide gamut, from spheroids to elongated bricks to the originally assumed Space Potatoes. This heterogeneity implies a variety of formation and possibly delivery mechanisms. In addition, while we assume that meteorites are a reasonably complete sample of the asteroid population, there may be dramatic differences in the meteorite delivery efficiency of these different objects.

Scattering Properties: Planetary radar observations typically transmit a single circular polarization and receive both orthogonal polarizations. Based on terrestrial and lunar studies, the relative partitioning of the received signal into "same as transmitted" (SC) and "opposite of transmitted" (OC) is expected to be determined by surface roughness, with a mirror give pure OC reflection. Surprisingly, this is the **only** radar scattering property that is clearly related to asteroid spectral type, with V-type and particularly E-type asteroids having much different scattering properties than the more common S- and C-type asteroids [4].

Summary: It is very difficult to make generalizations about the distribution of near-Earth asteroids. Their most distinguishing feature is the variety of structural properties seen, which seems to require a variety of production and evolution paths (including diverse collisional histories) to near-Earth space. This heterogeneity was largely discovered by observations at the Arecibo observatory over the last two decades. With the loss of that facility just as we expect the next generation of asteroid discovery programs (LSST, NEOSM) to ramp up, this window into the formation of Solar System objects will darken.

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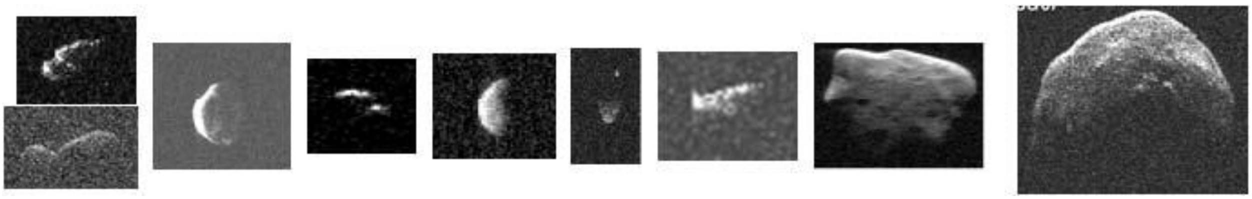

NEA shapes range from spheroidal, irregular, and elongated shapes to binaries and double-lobed objects and show various surface features including craters, ridges, boulders, and concavities.

References:

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