Arecibo Observatory planetary radar observations of near-Earth asteroid surfaces

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Abstract. We study the population of near-Earth asteroids (NEAs) using planetary radar at both Arecibo Observatory and Goldstone. Radar is uniquely suited for characterizing NEA surface properties as well as spin rates, sizes, and shapes of dozens of bodies yearly. Asteroids observed with the Arecibo Observatory planetary radar system reveal a variety of surface properties, ranging from metallic to stony in terms of composition, and rough to smooth. These properties do not always follow object size, shape, or rotation rate.
The NEAs we observe pass within a specific volume of space near the Earth, giving radar a sampling bias different from that of optical or thermal infrared surveys or lightcurve studies. Data were obtained at Arecibo Observatory between 1998 and present using S-band (λ=12.6 cm) radar by transmitting a continuous radio wave (CW) of monochromatic, circularly polarized signal and simultaneously measuring the strength of the echoes in both same (SC) and opposite sense (OC) polarizations[1]. A high polarization ratio indicates a rougher surface at the decimeter scale, which can be due to mineralogy and electric permittivity[2] as well as surface morphology (Benner et al. 2008) of the target asteroid. Preliminary analysis of these hundreds of bodies shows correlation between polarization ratio and asteroid spectral class, assigned based on color, spectral shape, and brightness[3]. We find decimeter-scale roughness in this population to be common, with smoother surfaces uncommon, similar to previous work[4]. Asteroid taxonomic classes cluster by polarization ratio: S-class, believed to be stony, asteroids have SC/OC values that cluster between 0.1 and 0.5; E- and X-class asteroids have values between 0.6 and 1.1, while M-class have values lower than 0.2. Measuring the polarization ratios determined with Arecibo planetary radar and thus the roughness of asteroid surfaces in the NEA population allows us to inform models regarding the history of particle sizes on NEA surfaces by constraining current regolith roughnesses. Surface roughnesses of near-Earth asteroids are important planning tools for current and future asteroid missions, such as OSIRIS-REx to Bennu, and future robotic and human spaceflight asteroid missions.

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