Understanding near-Earth asteroids: Is it in the details?

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Studies of near-Earth asteroids (NEAs) are important to our understanding of meteorites, impact probabilities for terrestrial planets, dynamics of the main belt, and asteroid surface processes. Crucial to these investigations is knowledge of the NEA size and albedo distributions and regolith properties; however, as we sample ever-smaller NEAs, we see an increasing variation in these physical properties. A notable diversity of shapes, surface features, and rotation states have been revealed by radar observations, whereas infrared observations have shown a range of spectral types and thermal characteristics. Although spacecraft missions will yield details for a few objects, and space-based surveys will result in important overviews, only ground-based observations can provide an overall understanding of the NEA population as a whole owing to the range of observing conditions (e.g., wavelength coverage, phase angle, heliocentric distance) they provide.

Radiometry is commonly used to infer both size and thermal properties, but necessary assumptions about the regolith, which controls thermal and (often) radar reflectance properties, can be especially dangerous for small NEAs because surface properties change as a function of size and irregular shapes play an increasingly important role. Our investigation combines thermal measurements with radar delay-Doppler imaging to better understand the regolith properties of different types of NEAs through detailed thermophysical modeling.

Over the past five years, we have measured the spectra of 53 NEAs at different phase angles and rotation phases to see how the inferred thermal properties depend on the detailed shape. The observations were carried out with SpeX at the NASA IRTF (0.8–4 microns) [1], which allows us to measure both the reflected and thermal contributions to the overall spectrum, thereby providing for a greater degree of self- consistency in the thermal modeling than infrared observations alone. The observed objects span a variety of spectral types: S-complex, C-complex, and X-complex, including two high-albedo (Tholen E-type) and two low-albedo (Tholen P-type) asteroids. Most of these objects were also observed with the Arecibo planetary radar. Although the quality of the radar data varies, for many of the objects we can determine the pole, spin state, and surface features from shape modeling without assuming a convex surface [e.g., 2,3]. These radar objects span a gamut of types, from nearly spherical to elongated or irregular shapes, single bodies to contact binaries to multiple-body systems, slow to fast rotators, and sizes from a few hundred meters to a few kilometers.

To study the properties of these NEAs, we have developed a thermophysical model, "SHERMAN", that uses the detailed shape to simulate multiple observations of an NEA at different viewing geometries, which we then compare to the actual infrared observations to infer the regolith properties. SHERMAN computes the local surface temperature for each facet on the asteroid at the time of observation, including self-shadowing, multiple scattering, and sub-scale roughness [modeled as small hemispherical craters following the methods of 4,5]. We will present an overview of our dataset as well as specific examples comparing our thermal modeling results to those from simple models such as NEATM [6] to illustrate some of the effects shape, observing geometry, and asteroid composition can have on the derived properties.

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