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Comparing diameters derived from radar and space-based infrared observations

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Abstract

We will expand on a preliminary study [1] from 2014 that compared the diameters of near-Earth asteroids measured in planetary radar images from Arecibo Observatory with diameters derived from thermophysical modeling of infrared data collected by the WISE and Spitzer spacecrafts. Revisiting the analysis with improved methods and expanded datasets from the last five years may provide new insights into the reliability of the assumptions made during the thermophysical modeling process.

1. Introduction

Radar observations provide direct measurements of the physical sizes of near-Earth objects, independent of visual albedo, composition, and thermal properties. As such, radar-observed asteroids can act as benchmarks for models of thermal-infrared emission by small bodies. Taylor et al. [1] previously compared the diameters measured for a subset of near-Earth asteroids observed both with the Arecibo planetary radar system and either the NEOWISE or ExploreNEOs programs, which use the WISE and Spitzer spacecrafts, respectively. Since 1998, the Arecibo planetary radar program has detected over 700 near-Earth objects (more than double the population available to [1]), including several dozen objects from the NEOWISE and ExploreNEOs catalogs, providing rotation-rate, size, and shape constraints depending on the strength and resolution of the received echoes.

2. Methods and Results

In [1], visible extents in radar images were measured by eye and translated to an effective spherical diameter; however, this step is nontrivial. For spheres, the diameter is simply twice the visible extent in a radar image, but, as the shape becomes more irregular, estimating the effective diameter of a three-dimensional object from a projected, two-dimensional radar snapshot becomes more difficult. The estimated diameters from radar compared to published diameters from NEOWISE and ExploreNEOs are shown in Fig. 1.

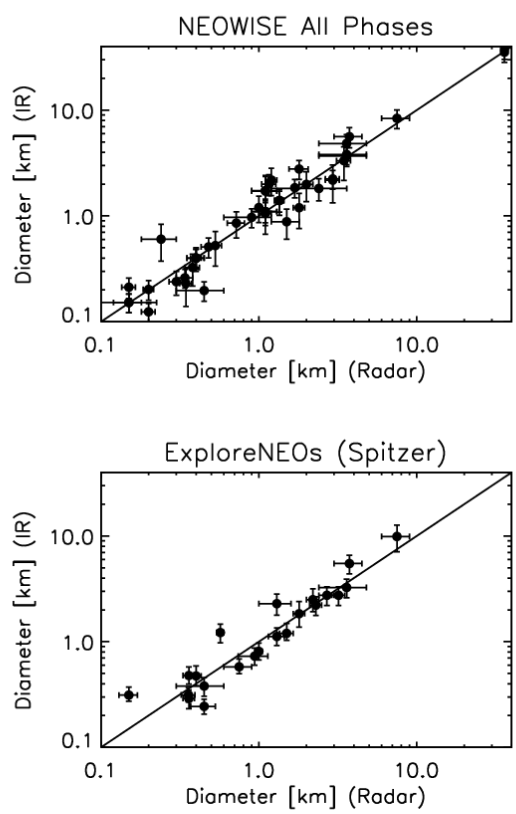

Figure 1. Results of [1] comparing diameters measured in Arecibo radar images to those derived from NEOWISE (cryogenic and warm phases) and ExploreNEOs (Spitzer) thermophysical modeling.

In this study, visible extents in radar images will be systematically measured by eye as well as with newly developed software (e.g., Fig. 2) that determines visible extents in a statistical manner. Attention will be paid to proper uncertainties on the measured values and to the correlation with the values from thermophysical modeling.

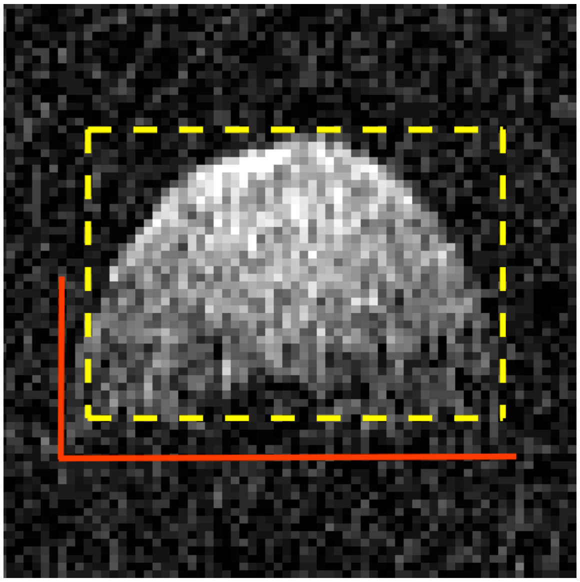

Figure 2. The yellow box encompasses the 2-sigma signal in a radar image of 3200 Phaethon and indicates a visible extent of 2.7 km. Red indicates a measurement by eye of a 3.0 km visible extent and slightly wider bandwidth.

Diameters from radar and infrared observations from [1] are generally in agreement, though some of the scatter suggests discrepancies of a factor of two or more. In some cases, the worst discrepancies are due to contact binaries or elongated objects, where the target can present an end-on or broadside silhouette that can significantly alter the effective observed diameter. We note, though, that mismatches can occur for even well-studied objects. For instance, thermophysical modeling of 3200 Phaethon [2] consistently suggests a diameter of 5.1 ± 0.2 km, yet Arecibo radar images (Fig. 2) of Phaethon revealed an equatorial diameter of roughly 6 km [3]. Even with a shape akin to 101955 Bennu, the spherically equivalent diameter is roughly 5.7 km, which remains inconsistent with the thermophysically derived diameter. The cause of this mismatch is not yet understood.

3. Summary

We will compare the diameters measured from radar to those derived from thermophysical modeling of space-based infrared observations using the greatly expanded observed populations from the five years since [1]. While we expect reasonable agreement between the techniques, we will give attention to the outliers and their sizes, shapes, compositions, and viewing geometries, all of which can affect the assumptions made in the process of standard thermophsyical modeling. Looking for inconsistencies will help us to understand the inherent uncertainties in diameters derived solely from thermophysical modeling.

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References

[1] Taylor, P., Howell, E., Nolan, M., Springmann, A., Vervack, R.J., Fernandez, Y.R., and Magri, C.: Comparing the diameters and visual albedos derived from radar and infrared observations, Asteroids, Comets, and Meteors Meeting, 524, 2014.

[2] Hanuš, J., et al., (3200) Phaethon: Bulk density from Yarkovsky drift detection, Astronomy & Astrophysics, 620, L8, 2018.

[3] Taylor, P., et al., Arecibo radar observations of near-Earth asteroid (3200) Phaethon during the 2017 apparition, Planetary and Space Science, 167, 1-8, 2019.