SPIN PERIODS OF NEAR-EARTH ASTEROIDS FROM INFRARED LIGHTCURVES. A. L. H. Lam[1], J. L. Margot[2,3], E. Whittaker[2], and N. Myhrvold[4], [1]Department of Electrical Engineering, UCLA, Los Angeles, CA (adrianlam0ho@ucla.edu), [2]Department of Earth, Planetary, and Space Sciences, UCLA, Los Angeles, CA, [3]Department of Physics and Astronomy, UCLA, Los Angeles, CA, [4]Intellectual Ventures, Bellevue, WA, USA

Introduction: The rotational period of an asteroid is a physical property that is important in a wide range of planetary science and space exploration contexts. A rotational period measurement is essential to the characterization of the rotational state [e.g., 1], which informs our understanding of an asteroid's interior and morphology [e.g., 2], dynamical evolution through the Yarkovsky and YORP effects [e.g., 3, 4], and the formation and evolution of multiple systems [e.g., 5, 6]. Spin periods also provide useful initial conditions when modeling the shape [e.g., 7, 8, 9] and thermophysical properties [e.g., 10] of asteroids. Spin rate distributions place bounds on the dynamical and collisional evolutions of the main belt of asteroids [e.g., 11], and therefore the characteristics of the near-Earth asteroid population, which governs the history of impact cratering in the inner solar system and affects planetary defense efforts.

The Near-Earth Object Surveyor Mission [12] is expected to yield infrared measurements of thousands of near-Earth asteroids (NEAs), potentially enabling the measurements of numerous NEA spin periods. Here, we use the Wide-field Infrared Survey Explorer (WISE) [13] data as a proof of concept for NEA spin period determination with infrared data. During its primary mission, the WISE spacecraft conducted a whole-sky infrared survey at four infrared bands (W1–4) centered at 3.4, 4.6, 12, and 22 µm. All 4 detectors were simultaneously exposed, producing up to 4 independent photometric measurements. The high-quality, multi-band IR observations of ~100,000 asteroids have been used to estimate asteroid diameters and albedos [e.g., 14]. Improved algorithms applied to a curated set of thousands of asteroids yielded refined estimates as well as estimates for asteroids not previously analyzed [15].

Methods: Waszczak et al. [16] used sparse photometry from the Palomar Transient Factory to determine ~9,000 reliable asteroid spin periods. Their method is conceptually simple. For each trial period, one fits a Fourier series model to the observed flux values and computes the sum of squares of the flux residuals. The Fourier series is truncated after the second harmonic, a simplification that rests on the assumption that the object is ellipsoidal in shape. Although this model is insufficient to capture the details of the lightcurve, it is perfectly adequate to recover the spin period in most instances, as verified with comparisons to high-quality (code 3) solutions published in the lightcurve database (LCDB) [17]. A random forest analysis helps determine which spin period estimates are most reliable.

Waszczak et al.'s method is directly applicable to WISE photometry, which typically contains at least 12–15 observations of each asteroid over a ~36-hour period. Although this observational cadence prevents the determination of spin periods for fast (<3.2 h) and slow (>18 h) rotators, most asteroids have spin periods that are amenable to characterization with this technique. We have implemented Waszczak et al.'s algorithm to the W4 data of the 94 NEAs among the 4420 asteroids analyzed by Myhrvold et al. [15].

Results: 47 out of 94 asteroids passed our data selection filters, which require a flux excursion of at least 0.3 mag and at least 12 measurements. 17 out of 47 yielded a suitable fit within the acceptable period range, according to specific metrics [16]. 5 out of 17 have an independent, high-quality-code (3 or 3-) LCDB estimate. Among these 5, the estimated spin period is correct within error bars for 3 NEAs. One estimate yielded a period that is twice that reported in the LCDB, and one NEA with the lowest SNR yields an incorrect period. We are still in the process of implementing a machine learning-based reliability estimator to assign a confidence level to each estimate. This estimator takes the SNR into account and may flag low-SNR estimates as low-confidence determinations. Two examples of folded lightcurves are shown in Figures 1 and 2.

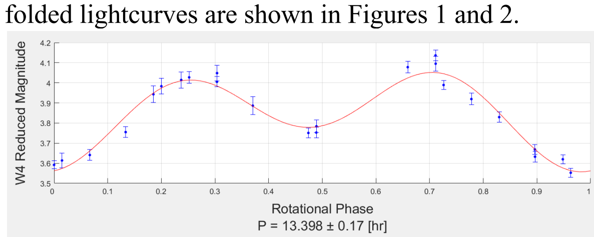

Figure 1: The folded lightcurve of NEA 88263 obtained by fitting W4 data. The LCDB estimate is 13.17 h.

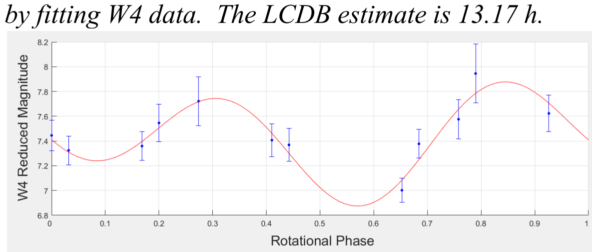

Figure 1: The folded lightcurve of NEA 153814. The LCDB estimate is 4.253 h.

Conclusions: In a preliminary analysis, we found that ~20% of NEAs in a curated WISE data set are amenable to spin period determinations. Approximately two thirds of these objects do not have a high-quality-code spin period estimate in the LCDB, and one third do not have any estimate at all, suggesting that infrared surveys have the potential to expand our knowledge of NEA spin periods and inform planetary defense efforts.

Improved spin period estimates may be obtained by combining spacecraft survey data with ground-based photometry data, as demonstrated by Durech et al. [18] for 1451 asteroids.

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