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SELECTION BIASES FOR DISCOVERING ASPHERICAL IMPACTORS WITH LSST

Abstract

Early discovery and characterization of asteroids are imperative for pre-impact determination and possibly preventing an impact altogether. Understanding survey biases that alter the detectability of near-Earth objects is thus foundational to planetary defense. Quantifying these selection biases is also necessary to calculate the overall impact hazards.

Levine & Jedicke (2023) showed that near-Earth asteroids with elongated shapes are less likely to be discovered by wide-field surveys than their spherical counterparts. The study demonstrated that this bias may help explain discrepancies in literature estimates on the number of decameter-scale near-Earth asteroids. Some surveys are more effective than others at detecting elongated objects, but this difference has been neglected in debiasing procedures.

The fact that elongated near-Earth objects are more difficult to detect has planetary defense implications because a large fraction of decameter-scale asteroids, the physical scale that spans both Tunguska-like and Chelyabinsk-like impactors, have axial ratios of at least 2:1. Thus, this previously overlooked survey bias has ramifications for identifying individual impactors as well as for estimating the total reservoir of near-Earth objects. Therefore, assessing the ability of modern asteroid searches to discover elongated objects is an important exercise for planetary defense.

Here, we expand on the research by Levine & Jedicke (2023) via a case study of the forthcoming Legacy Survey of Space and Time (LSST). The LSST will be executed by the under-construction Vera C. Rubin observatory and promises to expand the near-Earth object catalog by tenfold, a transformative advance in planetary defense. Using survey simulation software, we perform injection-recovery exercises with a population of near-Earth objects that exhibit high-amplitude lightcurve variability. We estimate the severity of the shape-driven selection bias in LSST by comparing the predicted discovery statistics versus a population of only spherical asteroids; we characterize the bias as a function of asteroid size and minimum object intersection distance (MOID) of the asteroids with Earth.

We conclude by discussing the broader implications of this research for planetary defense technology. In particular, we explore survey strategies that may help to mitigate this selection bias and estimate the change in lead-time that could be expected for impactors from LSST should those impactors have elongated shapes.