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THE ORBITAL PROPERTIES OF EARTH IMPACTORS

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ABSTRACT

We present a set of synthetic Earth impactors that are tailored to match the orbital properties of the impacting population. Realistic impactor orbits are crucial inputs to a variety of investigations, such as those that seek to discern how well and how early a particular asteroid survey can detect impactors, or to understand the progression of impact probability as an impactor is tracked after discovery. We will describe our method, which relies on Opik's b-plane formalism, and place it in context with previous approaches. While the Opik framework assumes the restricted three body

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problem with a circular Earth orbit, our final synthetic impactors are differentially corrected to ensure an impact in the N-body problem of the solar system. We test the validity of the approach through brute force numerical tests, and we demonstrate that our impactors are consistent with the observed velocity distribution of sporadic fireballs.

The impactor population is distinct from the NEO population, not only by virtue of the proximity of the asteroid orbit to that of the Earth, but also because low encounter velocities are strongly favored. Thus the impacting population has an increased prominence of low inclination and low eccentricity orbits, and Earth-like orbits in particular, as compared to the NEO population as a whole. This in turn leads to a different distribution on the sky, with stronger concentrations on the ecliptic near 90 degrees from opposition, especially when the distribution is weighted by the annualized probability of Earth impact.

Our synthetic impactors are based on the NEO model of Granvik et al. (Icarus 2018). The impactors are obtained by first culling the NEOs that do not pass close enough to Earth's orbit to afford an impact and then subsampling these potential impactors according to their annualized impact probability. With this approach we sample around 60,000 NEOs to capture one impactor. Following the Granvik et al. model, this approach also allows us to track which main-belt source region produced each impactor. This information allows us to quantify the relative contributions of the source regions for Earth impactors, which has implications for the physical characteristics of the impacting population.

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