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IDENTIFYING POSSIBLE BIAS IN ASTROMETRIC OBSERVATIONS OF POTENTIALLY HAZARDOUS ASTEROIDS AND OTHER HIGH RISK NEAR-EARTH OBJECTS

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Keywords: potentially hazardous asteroids, near-Earth objects, impact risk, astrometry, Gaia

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The IAU Minor Planet Center (MPC) hosts 250 million observations of Solar System Objects collected over centuries. The MPC has excellent quality control mechanisms in place that filter newly submitted data for errors. Identifying potential problems in past observations, such as the confusion of astrometric positions of Solar System Objects with those of nearby stars is less straightforward, but non-the-less a worthy endeavor, as past observations can torque current orbits. Even if astrometric observations are correctly attributed, stars close to the position of asteroids in the focal plane can cause a shift in the location of the measured photocenters that is rarely considered in astrometric practice. In this contribution we make use of the latest release of the Gaia astrometric catalog (EDR3) [1], [2] to identify past observations that could be affected by the presence of nearby stars. Of particular interest are objects on the NASA Jet Propulsion Laboratory, California Institute of Technology Center for Near-Earth Object Studies (CNEOS) Sentry Earth Impact Monitoring list.

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As of January 18, 2021, 22 near-Earth asteroids have both cumulative impact probability greater or equal 10^{-6}, and a cumulative hazard rating greater or equal "-4" in the Palermo scale. Only three of them, namely (29075), (99942) Apophis, and (101955) Bennu, have well-determined orbits. Half of the rest have data-arcs spanning less than a week. As very short arc orbits such as these are generally based on a small number of observations, each astrometric measurement has a considerable impact on the preliminary orbit of those objects. Thus, errors, in particular systematic ones, however small, can affect impact probability estimates.

We have identified those astrometric observations of the 22 asteroids on the Sentry Earth Impact Monitoring list that may have been affected by the presence of nearby stars. A 2D correlation between the differences $(O - C)$ calculated for each asteroid position and the direction to neighboring stars suggests the presence of a detectable bias. We show that this bias can be corrected via an analytic expression if additional observational data is available ($FWHM$, the actual difference in magnitudes between the stars and the asteroid) or through fitting the bias parameters under some assumptions on a per-observatory basis to $(O-C)$ values otherwise. The former alternative is preferred as the suggested bias is only one of the contributors to the systematic error budget.

Comments:

Submission for oral presentation.

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[1] Gaia Collaboration, A. G. A. Brown, A. Vallenari, T. Prusti, J. H. J. de Bruijne, C. Babusiaux, M. Biermann, et al., "Gaia Early Data Release 3: Summary of the contents and survey properties", ArXiv e-prints: 2012.01533, 2020.

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