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Detecting Dark Compact Objects in Gaia DR4: A Data Analysis Pipeline for Transient Astrometric Lensing Searches

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The Gaia satellite is cataloging the astrometric properties of an unprecedented number of stars in the Milky Way with extraordinary precision. This provides a gateway for conducting extensive surveys of transient astrometric lensing events caused by dark compact objects. In this work, we establish a data analysis pipeline capable of searching for such events in the upcoming Gaia Data Release 4 (DR4). We use Gaia Early Data Release 3 (EDR3) and current dark matter and astrophysical black hole population models to create mock DR4 catalogs containing stellar trajectories perturbed by lensing. Our analysis of these mock catalogs suggests that Gaia DR4 will contain about 4 astrometric lensing events from astrophysical black holes at a 5σ significance level. Furthermore, we project that our data analysis pipeline applied to Gaia DR4 will result in leading constraints on compact dark matter in the mass range $1 - 10^3\ M_\odot$ down to a dark matter fraction of about one percent.

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