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Fusing physics principles and machine learning: inferring dark matter densities of galaxies using stellar catalogs with incomplete kinematic information

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Galactic dynamics studies often face the challenge of incomplete kinematic information in stellar catalogs. This incompleteness poses a significant challenge to a complete and model-independent measurement of local galactic dark matter densities using stellar dynamics.
This talk presents two innovative approaches that fuse physics principles with machine learning techniques, specifically normalizing flows for stellar phase space density estimation, to overcome these limitations.
First, we demonstrate a method for measuring dark matter density on the disk of the Milky Way by leveraging equilibrium assumptions to compensate for missing stars obscured by intergalactic dust clouds and estimate the selection function: the probability of stars being included in the catalog.
Second, we introduce a technique for measuring dark matter density in distant dwarf spheroidal galaxies, utilizing spherical symmetry and equivariant normalizing flows to infer missing distance and proper motion data.
By augmenting incomplete data with physically motivated constraints and sophisticated machine learning models, our methods enable comprehensive analyses of galactic dark matter distributions.
We anticipate that these modern machine learning-based approaches will allow us to fully utilize the potential of current and future astronomical catalogs, significantly improving our understanding of galactic dark matter.

Track

Astrophysics

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