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Measuring Galactic Dark Matter through Unsupervised Machine Learning

Measuring the density profile of dark matter in the Solar neighborhood has important implications for both dark matter theory and experiment. In this work, we apply masked autoregressive flows to stars from a realistic simulation of a Milky Way-type galaxy to learn – in an unsupervised way – the stellar phase space density and its derivatives. With these as inputs we calculate the gravitational acceleration field and mass density directly from the Boltzmann Equation only assuming dynamic equilibrium. We demonstrate our approach can accurately reconstruct the mass density and acceleration profiles of the simulated galaxy, even in the presence of Gaia-like errors in the kinematic measurements. Finally, we discuss applications of this analysis to real astrometric data from Gaia Data Release 3.

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