Z111a JFlow: Model-Independent Spherical Jeans Analysis using Equivariant Continuous Normalizing Flows

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The kinematics of stars in dwarf spheroidal galaxies have been studied to understand the structure of dark matter halos. However, the kinematic information of these stars is often limited to celestial positions and line-of-sight velocities, making full phase space analysis challenging. Conventional methods rely on projected analytic phase space density models with several parameters and infer dark matter halo structures by solving the spherical Jeans equation. In this paper, we introduce an unsupervised machine learning method for solving the spherical Jeans equation in a model-independent way as a first step toward model-independent analysis of dwarf spheroidal galaxies. Using equivariant continuous normalizing flows, we demonstrate that spherically symmetric stellar phase space densities and velocity dispersions can be estimated without model assumptions. As a proof of concept, we apply our method to Gaia challenge datasets for spherical models and measure dark matter mass densities given velocity anisotropy profiles. Our method can identify halo structures accurately, even with a small number of tracer stars.