Contribution ID: **13** Type: **not specified**

Understanding Galactic Dark Matter with Neural Networks

Tuesday, 28 October 2025 16:20 (40 minutes)

Recent advances in machine learning (ML), particularly neural density estimation like normalizing flows, diffusion models, and flow matching, have opened new doors for high-precision, model-independent density estimation. These techniques are highly valuable for galactic dynamics studies, as they allow us to estimate the distribution of stars in phase space (position and velocity) without relying on traditional simplified models. By combining these ML-based stellar density estimates and equations of motion solvers for inferring gravitational fields, we can measure the local dark matter density in a model-independent way. This talk presents new research opportunities in this direction, focusing on modeling objects in our local universe using neural networks and using them for understanding local galactic dark matter distribution. 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 dark matter in the local universe.

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Session Classification: Session 4