International Conference on Machine Learning for Astrophysics 2nd Ed. - ML4ASTRO2

MACHINE LEARNING FOR ASTROPHYSICS
2ND EDITION CATANIA, 8-12 JULY, 2024

Contribution ID: **188** Type: **Oral Presentation**

EMBER: emulating baryons from dark matter-only simulations over cosmic time

Wednesday, 10 July 2024 10:20 (20 minutes)

Galaxy formation is fueled by inflowing gas from the cosmic web. While on cosmological scales the gas distribution traces the dark matter, the relation between gas abundances and matter decouples at galactic scales and transitions into a highly non-linear regime due to the complex interplay of various astrophysical processes.

Hydrodynamical simulations are currently the most accurate tool to model the co-evolution of dark matter and baryons but are expensive, often do not provide enough constraining statistics and do not probe the entire dynamic range of galaxy masses. Thus, fast and accurate models breaking this trade-off are needed to drive progress.

I will introduce the Emulating Baryonic EnRichment (EMBER) framework, a neural network based approach, that can predict high-resolution baryonic fields like HI from low-resolution dark matter simulations. Designed as stochastic emulators, multiple realizations can be sampled for the same dark matter field, highlighting the statistical power of the approach. The model allows to create cheap mock fields with similar properties to full hydrodynamical simulations of galaxy formation, while operating on a fraction of the computational cost.

I will demonstrate that EMBER can reproduce gas and HI masses of dark matter haloes across 5 orders of magnitude probing beyond the regime of abundance matching models down to dwarf galaxies. I will outline how EMBER can be extended to include velocity information for a more precise dynamical modeling of galactic in- and outflows as well as additional gas fields, like H2, of particular importance to star formation and galaxy evolution.

Presenter: BERNARDINI, Mauro (University of Zurich)

Session Classification: Cosmology & Simulations