Dynamic Diffusion Schrödinger Bridge in Astrophysical Observational Inversions

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Main Takeaways

- From the Astrophysics perspective:

  A novel ML framework that improves interpretability, learning efficiency, and prediction performance for Giant Molecular Clouds (GMCs) systems in star formation studies.

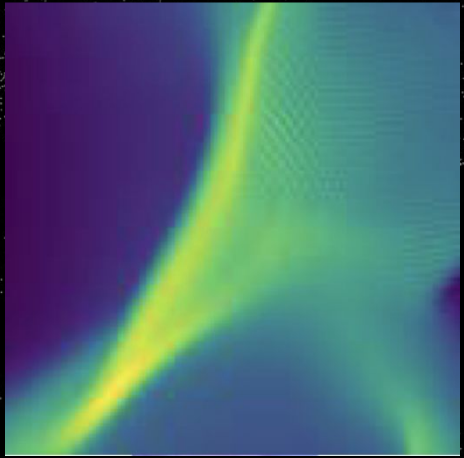
- From the Machine Learning perspective:

  A tailored diffusion Schrödinger bridge (DSB) model with a pairwise domain, showing strong advantages in Out-Of-Distribution (OOD) generalization for scientific inverse tasks.

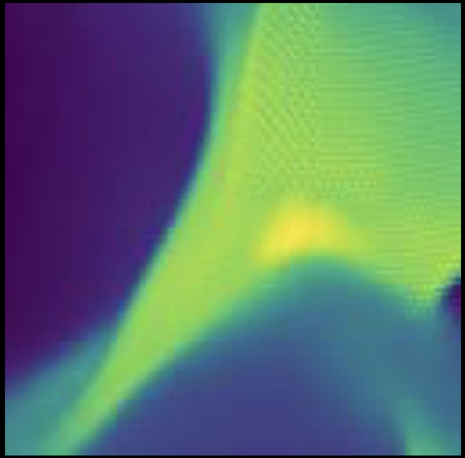
Problem and Objective

Task goal: Infer true physical quantities
(e.g., density, magnetic field) from observational data.

Observations

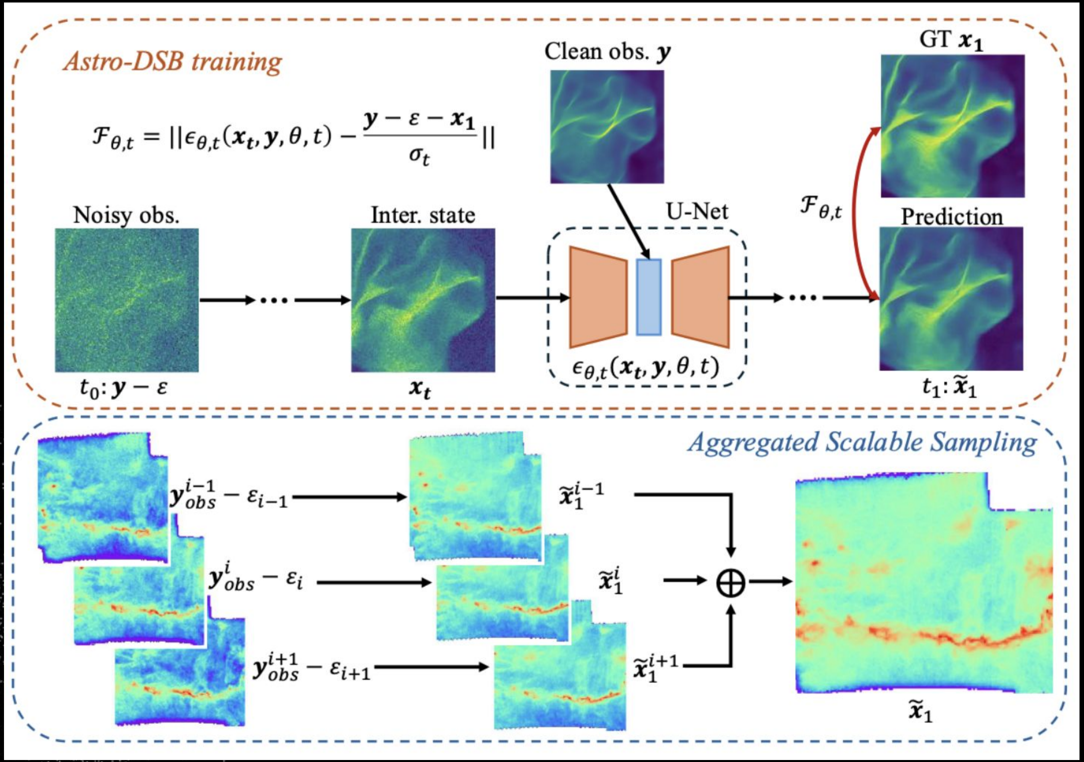


Physical
distributions

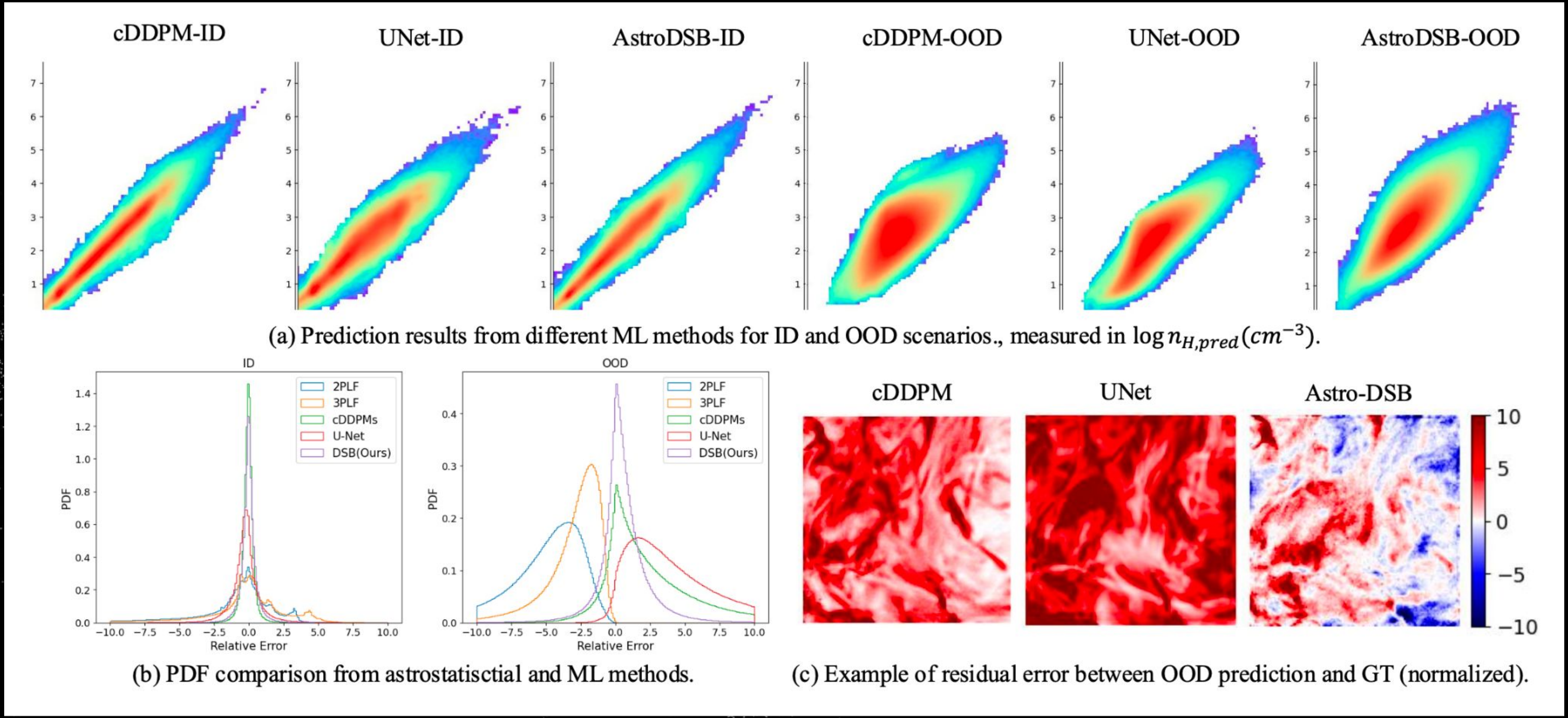


Astro-DSB Framework

- **Core idea:** Distributional mapping under optimal transport (OT) between observation and true physical distributions
- **Training:** Pairwise training under a conditional DSB model
- **Inference:** Aggregated scalable sampling for large-scale observational data



Key Results Compared to Conventional Methods



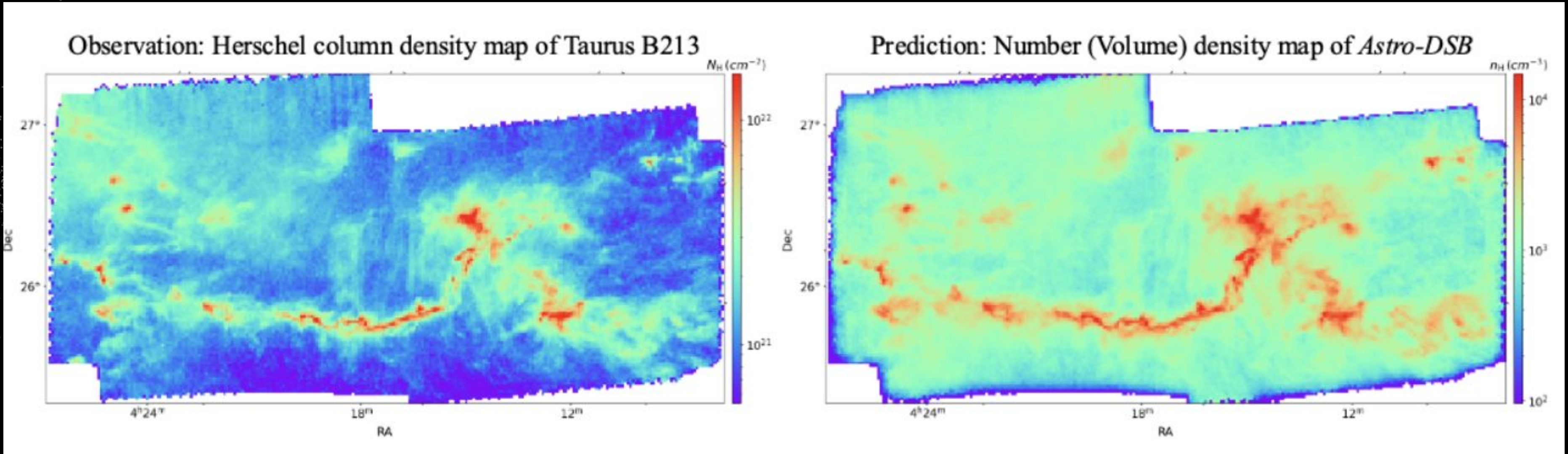
(a) Prediction results from different ML methods for ID and OOD scenarios., measured in $\log n_{H,pred}(cm^{-3})$.

(b) PDF comparison from astrostatisctial and ML methods.

(c) Example of residual error between OOD prediction and GT (normalized).

Extension to Real Observational Data from Taurus B213

Astro-DSB produces consistent results with independent astrophysical methods on real observations.



Thank you!

Please find more details in our paper and code below, and looking forward to meet you at our poster session!

Paper

Code