Bayesian inference of 3D densities of galactic H_I and H_2

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Motivation

The detailed **3-dimensional structure of the Milky Way** is still very uncertain but important for interpreting other measurements, for example cosmic-rays or gamma-ray diffuse emission.

1. We aim at inferring **atomic hydrogen** densities in the Galaxy by mapping observed Doppler-velocities of **21-cm emission** to positions in the galaxy [1, 2]
2. Inferring **molecular hydrogen** densities from **CO-emission** using the same principle [3, 4]
3. Breaking distance ambiguity by enforcing **correlations between neighbouring lines of sight** using novel Bayesian inference techniques [5]

Summary

We inferred **3-dimensional gas densities** of atomic and molecular hydrogen in the Milky-Way together with the **galactic velocity field**.

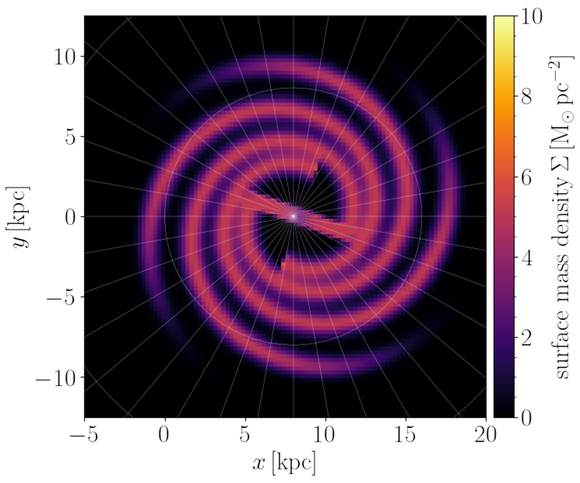
1. **Excellent local resolution** by employing a log-radially spaced grid
2. Enforcing a correlation structure helps with breaking distance ambiguity, but not enough to strongly constrain the galactic velocity field

→ Could be improved by additional data-constraints, e.g. correlations with dust, to constrain gas densities or galactic masers to constrain velocities

3. Total inferred mass: $M_{\mathrm{H_I}} = 3.16 \times 10^9\,\mathrm{M}_\odot$, $M_{\mathrm{H_2}} = 7.10 \times 10^8\,\mathrm{M}_\odot$

Test of H_I-channel with a mock-setup

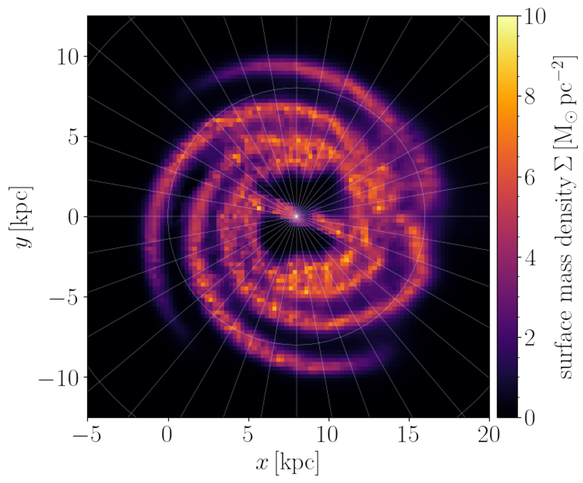
Ground truth gas density



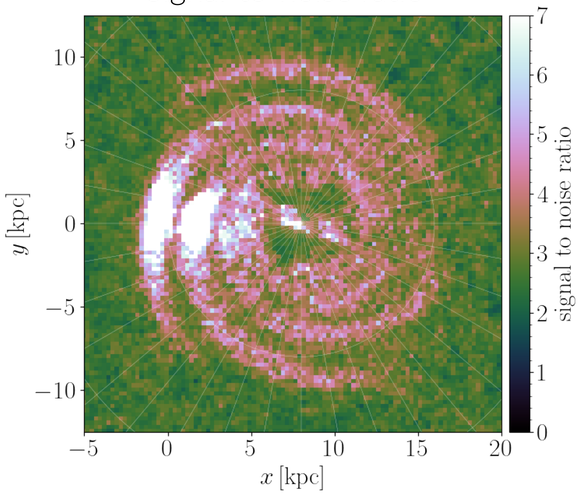
1. **Create ground truth** gas density that looks like a spiral
2. **Compute mock data** from ground truth and add random white noise
3. **Reconstruct gas density** using only the mock-data

→ Reconstruction performs exceptionally well nearby but fails in regions behind the galactic centre.

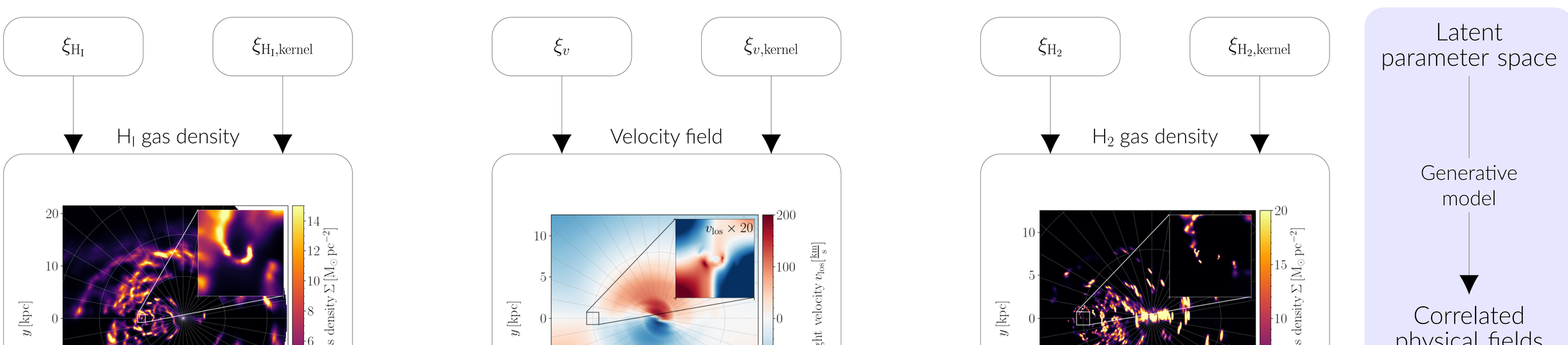
Reconstructed gas density



Signal-to-noise ratio



The forward model



References

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