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Multi-Tracer Inference of the Epoch of Reionisation and Cosmic Dawn

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Understanding the epochs of cosmic dawn and reionisation requires us to leverage multi-wavelength and multi-tracer observations, with each dataset providing a complimentary piece of the puzzle. To interpret such data, we update the public simulation code, 21cmFASTv4, to include a discrete source model based on stochastic sampling of conditional mass functions and semi-empirical galaxy relations.

We demonstrate that our new galaxy model is flexible enough to characterize very different predictions from hydrodynamic cosmological simulations of high-redshift galaxies.
Combining a discrete galaxy population with approximate, efficient radiative transfer
allows us to self-consistently forward-model galaxy surveys, line intensity maps (LIMs), and observations of the intergalactic medium (IGM).

Not only does each observable probe different scales and physical processes, but cross-correlation will maximise the information gained from each measurement by probing the galaxy-IGM connection at high-redshift. Scatter in galaxy properties can be constrained using UV luminosity functions and/or 21cm power spectra, especially if astrophysical scatter is higher than expected (as might be needed to explain recent JWST observations).
Our modelling pipeline is both flexible and computationally efficient, facilitating high-dimensional, multi-tracer, field-level Bayesian inference of cosmology and astrophysics during the first billion years.

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