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Learning the Reionization History from High-z Quasar Damping Wings with Simulation-based Inference

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The damping wing signature of high-redshift quasars in the intergalactic medium (IGM) provides a unique way of probing the history of reionization. Next-generation surveys will collect a multitude of spectra that call for powerful statistical methods to constrain the underlying astrophysical parameters such as the global IGM neutral fraction as tightly as possible. Inferring these parameters from the observed spectra is challenging because non-Gaussian processes like IGM transmission causing the damping wing imprint make it impossible to write down the correct likelihood of the spectra.

We will present a simulation-based HMC inference scheme based on realistic forward-modelling of high-redshift quasar spectra including IGM transmission and heteroscedastic observational noise. To this end, we train a normalizing flow as neural likelihood estimator as well as a binary classifier as likelihood ratio estimator and incorporate them into our fully differentiable JAX-based inference pipeline.

We provide a reionization constraint forecast for Euclid by applying our procedure to a set of mock observational spectra resembling the distribution of Euclid quasars and realistic spectral noise. By inferring the IGM neutral fraction as a function of redshift, we show that our method can robustly constrain its evolution up to ˜5% at all redshifts between 6 and 11.

Brainstorming idea [title]

Mitigating overconfidence in scientific SBI applications

Brainstorming idea [abstract]

Simulation-based inference (SBI) has become a powerful tool to constrain astrophysical and cosmological parameters when the likelihood is only available implicitly though computationally expensive simulators. Many SBI algorithms, however, suffer the caveat of overconfidence and do not necessarily guarantee faithful representations of the posterior density, a problem that is not always addressed beyond the theoretic SBI literature. We would like to encourage a detailed discussion about state-of-the-art inference testing and diagnostics to raise awareness in the HEP/Astro/Cosmo community and agree upon unified standards that can serve as a guideline for future SBI applications in the natural sciences.

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