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21cmEMU: an emulator of 21cmFAST summary observables

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Recent years have witnessed rapid progress in observations of the Epoch of Reionization (EoR). These have enabled high-dimensional inference of galaxy and intergalactic medium (IGM) properties during the first billion years of our Universe. However, even using efficient, semi-numerical simulations, traditional inference approaches that compute 3D lightcones on-the-fly can take 10^5 core hours.

Here we present 21cmEMU: an emulator of several summary observables from the popular 21cmFAST simulation code. 21cmEMU takes as input nine parameters characterizing EoR galaxies, and outputs the following summary statistics: (i) the IGM mean neutral fraction; (ii) the 21-cm power spectrum; (iii) the 21-cm spin temperature; (iv) the sky-averaged (global) 21-cm signal; (v) the ultraviolet (UV) luminosity functions (LFs); and (vi) the Thomson scattering optical depth to the cosmic microwave background (CMB). All observables are predicted with sub-percent median accuracy, with a reduction of the computational cost by a factor of over 10000.

After validating inference results, we showcase a few applications including: (i) quantifying the relative constraining power of different observational datasets; (ii) seeing how recent claims of a late EoR impact previous inferences; and (iii) forecasting upcoming constraints from the sixth observing season of the Hydrogen Epoch of Reionization Array (HERA) telescope.

21cmEMU is publicly-available, and is included as an alternative simulator in the public 21CMMC sampler.

Research area

Epoch of Reionization

Primary author: BREITMAN, Daniela (Scuola Normale Superiore (SNS))

Presenter: BREITMAN, Daniela (Scuola Normale Superiore (SNS))

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