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Extracting the Global Cosmological 21-cm Signal From EDGES Data Using MCMC

Raul A. Monsalve[1,2,3], Judd D. Bowman[2], Alan E.E. Rogers[4], Thomas J. Mozdzen[2], and Nivedita Mahesh[2]
(1) University of Colorado Boulder, Boulder, CO 80303, USA, e-mail: raul.monsalve@colorado.edu
(2) Arizona State University, Tempe, AZ 85287, USA
(3) Universidad Católica de la Santísima Concepción, Concepción, CHILE
(4) Haystack Observatory, Westford, MA 01886, USA

The 21-cm spectral line emitted by neutral hydrogen in the intergalactic medium (IGM) at redshifts > 6, can be used to characterize the first generations of stars, galaxies, and black holes in the Universe. Due to redshift, the 21-cm signal is expected at frequencies < 200 MHz for z > 6. The Experiment to Detect the Global EoR Signature (EDGES) measures the sky-average, or global, brightness temperature spectrum in the frequency range 50-200 MHz, with the objective of characterizing the cosmological 21-cm signal. The EDGES instruments are single-antenna, absolutely-calibrated, total-power radiometers. They conduct observations from the Murchison Radio-astronomy Observatory in Western Australia.

With EDGES, we are currently conducting refined analyses of the most recent data in order to separate with precision the contributions to the total sky temperature from the cosmological 21-cm signal, the astrophysical foregrounds, and potential residuals from imperfect instrument calibration. This separation is performed through a Markov Chain Monte Carlo (MCMC) exploration, and relies on accurate models for all the contributions to the total temperature. In particular, although the sky-average 21-cm signal is about four orders of magnitude smaller than the intensity of the foregrounds, the signal has sharp spectral features that contrast significantly with the spectral smoothness of the foregrounds. This is a key aspect that enables the extraction of the 21-cm signal. Small errors in the parameters assumed for instrument calibration, such as receiver gain and offset, antenna and receiver impedance mismatch, and frequency dependence of the antenna beam, could potentially mimic more closely the spectral characteristics of the 21-cm signal and, therefore, have to be carefully accounted for in the analysis.

In this talk I will describe our analysis pipeline for extraction of the 21-cm signal from the EDGES data using MCMC. I will describe the signal models, the parameters, and the separation technique. The EDGES datasets consist of three years of observations using different instruments in different hardware configurations. The spectra are captured at a raw resolution of 6.1 kHz, and over 24 hours of local sidereal time, which provides the opportunity to take advantage of the daily drift of the foregrounds over the instrument's field of view, to separate them from the isotropic and time-invariant global 21-cm signal.