The Cosmic Twilight Polarimeter

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The Cosmic Dawn is a poorly understood frontier in modern cosmology brought forth by the first luminous sources that emerged in the universe between the epoch of recombination and the end of the epoch of reionization. These first stars and galaxies formed from local over densities in the primordial Intergalactic Medium (IGM) that would eventually grow into the large-scale structure of the universe we can now observe. The most promising experiments to understand this period are observations of the redshifted 21-cm line emission of neutral atomic hydrogen (HI) that composes the bulk of the early IGM. Ionizing radiation emitted by these luminous sources couples to the local IGM which theory suggests would leave a telltale signal that tracks the early formation of the universe. Recent efforts to observe this signal have split into two general approaches, power spectrum measurements of HI spatial distributions using interferometers and integrated all-sky observations of the global 21-cm signal using single dipole total-power measurements.

Different from conventional total-power global 21-cm experiments, we propose the use of projection-induced polarization as a means to constrain the intervening Galactic foreground spectrum, which is 4-5 orders of magnitude greater than the expected background 21-cm signal. The induced polarization arises from projection of anisotropic off-boresight sources onto the antenna plane. This polarization is distinct from the intrinsic polarization from foreground synchrotron emission, which is much weaker in magnitude. More importantly, since the background signal is expected to be isotropic, our simulation suggests that the observed polarization provides information in constraining the foreground spectrum directly. The Cosmic Twilight Polarimeter (CTP) is a proof-of-concept instrument designed to operate at frequency range of 65-85 MHz, located at the Green Bank Observatory (GBO), WV, USA. The instrument consists of a dual-polarized antenna, equipped with active thermally stabilized front-end electronics and a network-theory based transducer gain calibration scheme. We will present the evaluation on instrument stability and effectiveness of the induce polarization approach.