Toward Experimental Evidence of Cosmic Dawn

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Cosmic Dawn may be defined as the era following global recombination at which the gas kinetic temperature of the diffuse pre-galactic medium (PGM) reached its lowest, prior to global heating by X-ray from cinders of stellar evolution. This is also the era in which copious Lyα fluxes generated by the stars first suffused the early Universe. The theorized Wouthuysen-Field effect predicts Lyα coupling of the spin temperature (TS) of the ground state of hydrogen in the PGM to the gas temperature, the result of which is a predicted O(100mK) absorption feature in the spectrum of the CMB averaged over the sky (e.g., Pritchard & Loeb 2012, Rep. Prog. Phys., 75, 086901). As well as timing the formation of early generation

Measurement of the zero-mode via all-sky radiometry and high-order spatial modes via interfereometry is difficult largely because synchrotron foregrounds are thousands of times stronger than PGM signatures. Moreover, the foregrounds are poorly known, and VHF antennas are intrinsically difficult to calibrate. The Large Aperture Experiment to Detect the Dark Age (LEDA) has been working the problem at the Long Wavelength Array (LWA) station near the VLA and most recently at the Caltech Owens Valley LWA station.

Bowman et al. (2018, Nature, 555, 67) reported detection of an unexpectedly strong zero-mode absorption signal at $16 < z < 20$. The inferred TG is about half that predicted if cooling after global recombination was adiabatic (Figure 1). Barkana (2018, Nature, 555, 71) has argued that cold dark matter could provide a heat sink if non-gravitational interactions with baryonic matter are possible.

That a detectable radio signal from cosmic dawn could be tied to the particle properties of dark matter is potentially revolutionary, and confirmation (or disconfirmation) of the report by Bowman et al. is critically important owing to the difficult of measurement and the surprising spectral profile: “too” strong, too wide, and flat-bottomed over a broad range of redshift.

Price et al. (2018, MNRAS, 478, 4193) reported on LEDA instrumentation c. 2016 and the data reduction path applied to a few hours of data from three radiometers operating simultaneously. I will report on data analysis and improvements accomplished since then to (i) the radiometers, boosting the time and temperature stability of noise diode references, and extending the useful science pass band upward to 87.5 MHz, (ii) detailed calibration of the signal path from the antennas to the digital samplers, and (iii) an alternate description of performance characteristics when the LNAs are mated with reactive RF sources.