Detecting the Peak of the Cosmological 21 cm Signal

Andrei Mesinger[1] and Aaron Ewall-Wice[2]
(1) Scuola Normale Superiore, Piazza dei Cavalieri 7, 56126 Pisa, Italy
(2) Dept. of Physics and MIT Kavli Institute, Massachusetts Institute of Technology, Cambridge, MA 02139 USA

21 cm tomography promises to shed light on the formation of the first stars, galaxies, and black holes in the coming years. A number of radio interferometers are already taking data in an effort to detect the diffuse HI signal during the epoch of reionization using statistical measures such as the power spectrum.

An era that has received relatively little observational attention is immediately preceding reionization: the epoch or X-ray heating. During this time, the large mean offset between the intergalactic medium's HI spin temperature and the cosmic microwave background drives the power spectrum of brightness temperature fluctuations, sourced by heating, to over an order of magnitude above the reionization signal (Pritchard & Furlanetto, 2007) in a majority of reasonable models. This large power spectrum amplitude makes the signal potentially just as accessible as the reionization signal from a thermal sensitivity standpoint. During the completion of this work Christian & Loeb (2013) found that the 128 Tile Murchison Widefield Array has the sensitivity to constrain heating of the intergalactic medium for a variety of X-ray efficiencies. This work extends these results to a much larger space of heating histories, redshifts, and interferometers.

We perform semi-numeric parameter studies of the heating epoch, varying the X-ray efficiency, along with the halo masses hosting galaxies, Mmin. Using a simple relation between the Warm Dark Matter particle mass and Mmin, we are also able to explore popular models of warm dark matter. Simulating the sensitivity of arrays currently performing observations we find that detections of comparable signal to noise to reionization are possible during the epoch of X-ray heating which could help to constrain cosmology and the nature of the first astrophysical X-ray sources. We find that a next generation instrument such as the Square Kilometer Array will easily access the X-ray heating signal over the entire parameter space that we consider. Our simulations are the first to treat many existing arrays on equal footing and to cover a robust parameter space making them an excellent gauge on the detectability of reionization as well.