



Chasing the Cosmic Dawn with LEDA experiment: latest improvements in data and systematics characterisation

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At Cosmic Dawn, the appearance of the first astrophysical sources and the subsequent X-ray heating by this emerging population is predicted to give rise to an absorption dip in the sky-averaged 21cm signal of neutral hydrogen that can be detected at low frequencies against a radio background. With the aim of measuring this global 21cm signal, different precision radiometry experiments have been planned or are already observing with a diversity of instrument design and with not unanimous results: the EDGES team detection of an absorption profile has not been confirmed by the recent SARAS3 results.

This talk focuses on the Large aperture Experiment to detect the Dark Ages (LEDA) [1], located at the Owens Valley Radio Observatory and among the few experiments to have compiled data, and corresponding variation in environmental conditions, over several years of observational campaigns. Using LEDA data, [2] constrained the amplitude (< -890 mK) and 1σ width (> 6.5 MHz) of a Gaussian model for the absorption trough with 95% confidence. [3] measured the spectral index β of the Northern sky from 60 to 87 MHz, obtaining a value ranging from -2.48 at LST ~ 10 h to a steeper -2.54 at LST ~ 13 h, with a standard deviation of 0.06.

The main challenge in measuring the 21 cm signal is the subtraction of the bright foregrounds, usually fitted jointly with the 21cm signal in a Bayesian framework [2]. The successful characterisation of possible absorption feature parameters from the measured spectra requires, however, detailed understanding of the large number of possible sources of systematic errors. Accurate electromagnetic simulations of antennas, ground screen and soil composition are foremost within project-specific efforts.

In this talk we describe a new, more realistic model of the LEDA antenna gain patterns, and the effect that uncertainties in the antenna modelling has on measured spectra and, ultimately on the detection of the 21cm signal. A complete characterisation of the LEDA data is a valuable resource to guide future instrument design and to improve our knowledge of the high redshift Universe.

References

- [1] D.C. Price, L.J. Greenhill, A. Fialkov, G. Bernardi, H. Garsden, B.R. Barsdell, J. Kocz, M.M. Anderson, S.A. Bourke, J. Craig, M.R. Dexter, J. Dowell, M.W. Eastwood, T. Eftekhari, S.W. Ellingson, G. Hallinan, J.M. Hartman, R. Kimberk, T. Joseph W. Lazio, S. Leiker, D. MacMahon, R. Monroe, F. Schinzel, G.B. Taylor, E. Tong, D. Werthimer, D.P. Woody, "Design and characterization of the Large-aperture Experiment to Detect the Dark Age (LEDA) radiometer systems", *Monthly Notices of the Royal Astronomical Society*, **478** 4193-4213 (2018), doi: 10.1093/mnras/sty1244.
- [2] G. Bernardi, J.T.L. Zwart, D.C. Price, L.J. Greenhill, A. Mesinger, J. Dowell, T. Eftekhari, S.W. Ellingson, J. Kocz, F. Schinzel, "Bayesian constraints on the global 21-cm signal from the Cosmic Dawn", *Monthly Notices of the Royal Astronomical Society*, **461** 2847-2855 (2016), doi: 10.1093/mnras/stw1499.
- [3] M. Spinelli, G. Bernardi, H. Garsden, L.J. Greenhill, A. Fialkov, J. Dowell, D.C. Price, "Spectral index of the Galactic foreground emission in the 50-87 MHz range", *Monthly Notices of the Royal Astronomical Society*, **505** 1575-1588 (2021), doi: 10.1093/mnras/stab1363.