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Exploring the sky-averaged 21-cm line from the South African Karoo using REACH

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The cosmological 21-cm signal reported by EDGES [1] in 2018 is centred at 78 MHz, z=17 and is at least twice as intense as predicted by standard astrophysical modelling, thus requiring stronger than expected contrast between the background radiation and the kinetic gas temperature. To explain this feature exotic mechanisms have to be invoked such as non-gravitational interaction between dark matter and baryons which leads to extra cooling of the gas or an excess radio background relative to the CMB which could be produced either by exotic astrophysical sources or by particle decay. On the other hand, several groups have voiced concerns on the data analysis presented by EDGES, which uses a basic foreground model fit with non-physical parameters.

The spectral and spatial structure of the foregrounds couple with the spectral and spatial variations of the antenna on the ground, resulting (even for a simple dipole antenna) on antenna temperature variations hardly modelable with a simple low order polynomial, and highly dependent on LST and integration times. In order to tackle the aforementioned concerns over the EDGES results, REACH has been designed to use physics rooted foreground and instrument models that will be jointly fitted, in a Bayesian manner, with the cosmic signal models. The aim of this approach is to be able to explain any residual instrument systematics. Furthermore, REACH is a wide band experiment covering both the Cosmic Dawn and the Epoch of Re-ionization (z = 7-28). REACH uses a nested sampling too and parametric foreground, instrument and 21-cm signal models for the signal detection. The pipeline is currently under development. REACH also features a switched calibrator RF receiver using in-field measurements of the analogue and digital components on the receiving chain. The calibration of the receiver is also done using a Bayesian tool. The spectrometer features 6 kHz-wide channels (for RFI excision) and is based on the SKA1-LOW Tile Processing Module FPGA board. REACH is currently being deployed in the RFI-quiet Karoo radio reserve in South Africa, location of the HERA experiment, MeerKat, and the future SKA1-Mid. REACH will commence observations in 2021 using the phase I system: 2 antennas (but no simultaneous observations). The antennas: a conical log-spiral antenna and a hexagonal dipole have been chosen by maximising the log evidence (in a Bayesian sense) of needing a 21-cm signal model to explain the data and minimising the error difference between the detected signal and the recovered signal in a simulated pipeline.

In this presentation we will discuss the progress of REACH and will focus on the experimental approach and simulated performance predictions.

References

[1] Bowman, J., Rogers, A., Monsalve, R. et al. An absorption profile centred at 78 megahertz in the sky-averaged spectrum. Nature 555, 67–70 (2018). https://doi.org/10.1038/nature25792

[2] E. de Lera Acedo, "REACH: Radio Experiment for the Analysis of Cosmic Hydrogen," 2019 International Conference on Electromagnetics in Advanced Applications (ICEAA), Granada, Spain, 2019, pp. 0626-0629, doi: 10.1109/ICEAA.2019.8879199.