MEASURING THE 21-CM GLOBAL SIGNAL FROM THE LUNAR FARSIDE USING POLARIZATION AND TIME-DEPENDENCE

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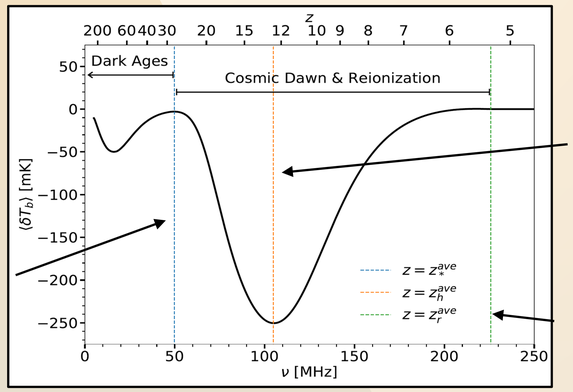
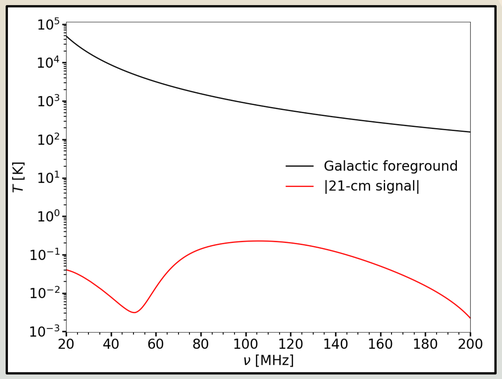
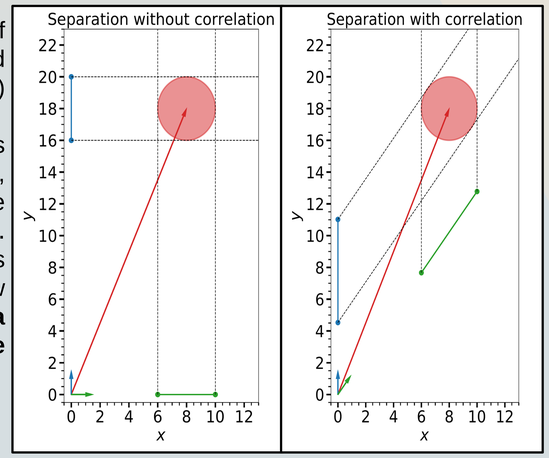
Introduction

Hydrogen's spin-flip transition emits and absorbs photons of frequency (wavelength) 1420 MHz (21 cm). It interacts with the photons in the early universe, generating ripples in the Cosmic Microwave Background (CMB) in the 10-200 MHz frequency range, known as the 21 cm global signal.





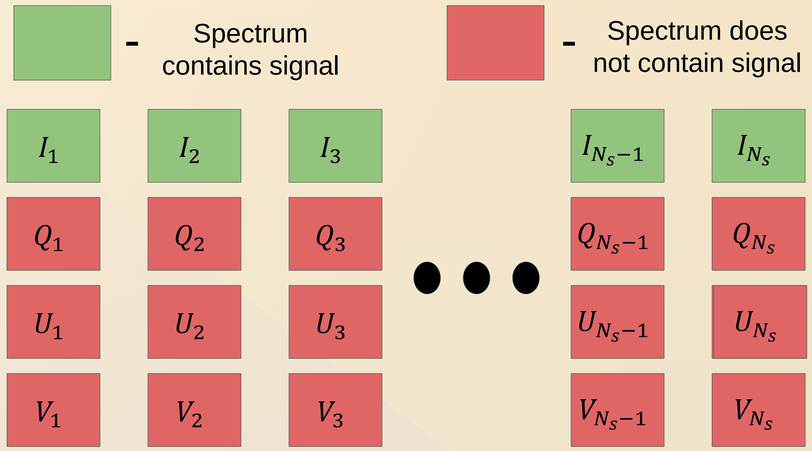
The 21-cm signal must be measured in the presence of immense foreground radiation from the Milky Way galaxy. The key problem to solve in measuring the global 21-cm signal is separating the signal from the foreground emission.



Schematic separation of data (red) into foreground (blue) and signal (green) components.
Left: When components are orthogonal, uncertainties (line segments) are minimal. *Right*: When components overlap, uncertainties grow significantly. **We want a strategy with as little foreground-signal overlap as possible.**

Decreasing overlap between signal and foreground

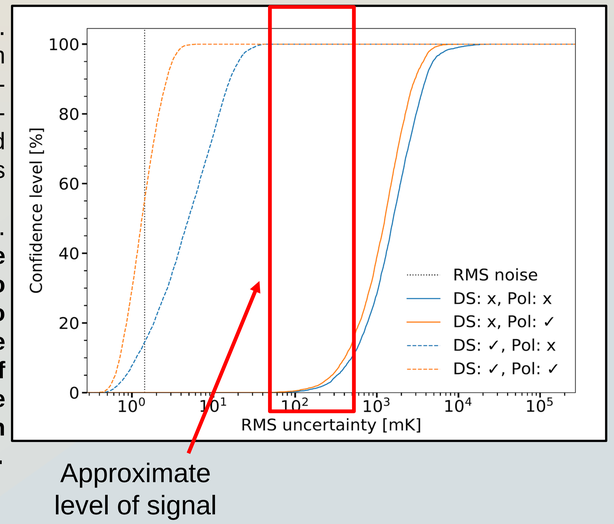
To make a global signal measurement both more precise and more robust, we must decrease the overlap between the foreground and signal, i.e. make them appear more differently in the data. We do this by **measuring many spectra at different times and by measuring all four Stokes parameters to gain polarization information**.



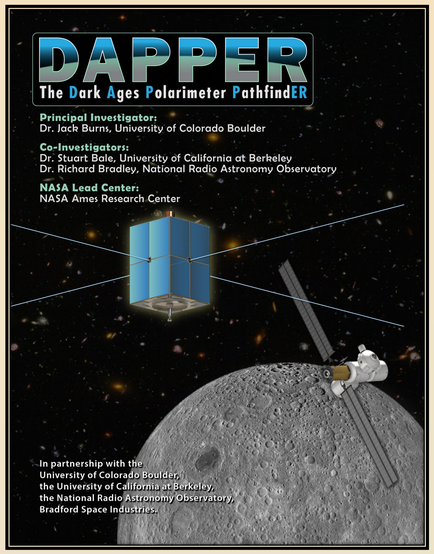
Schematic diagram showing the spectra to analyze, including data from N_s time bins and all four Stokes parameters. All total power (Stokes I) spectra contain the signal identically and all other Stokes parameters do not include it at all. The foreground contributions to the $4N_s$ spectra are unique.

Using a training set-based pipeline designed in Tauscher et al. (2018), we computed the connection between RMS uncertainties and percentage confidence levels with and without polarization and with and without multiple time bins.

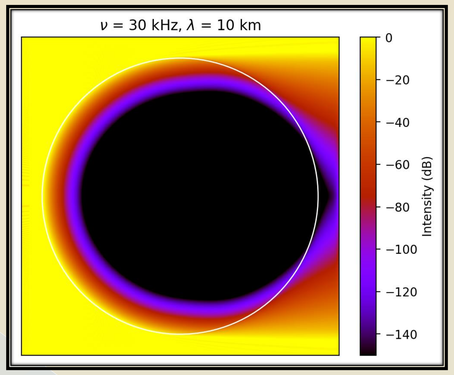
RMS uncertainties vs. confidence level with and without time-dependence (Drift-Scan, DS) and with and without full Stokes polarization measurements (Pol). **For a high confidence (e.g. 95%) interval to contain useful info about the signal, the time dependence of the data must be analyzed. Polarization provides added value.**



Using new approach to measuring the global signal



The Dark Ages Polarimeter PathfindER (DAPPER) is a mission concept submitted to NASA after a concept study funded through the Astrophysics SmallSat program. DAPPER's principal investigator is Jack Burns and all authors of this poster are co-investigators or collaborators. DAPPER is meant to complement ground-based instruments like EDGES by observing at lower frequencies from behind the Moon and with a different antenna design. See also Burns (2020) and forum talk by Jack Burns.



N. Bassett has simulated (see Bassett et al. 2020) the level of RFI attenuation caused by the Moon using its average electrical properties, showing that the farside of the Moon achieves attenuation of radio frequency interference >80 dB relative to open space a Moon's distance away from Earth.

Conclusions

The optimal analysis strategy for a global 21-cm signal experiment includes data from many different time bins and includes full Stokes measurements. DAPPER (and its prototype the Cosmic Twilight Polarimeter, CTP, see Nhan et al. 2019) will be the first experiment to utilize this strategy.

This is a short summary of the work presented in Tauscher et al. (2020). This work is directly supported by the NASA Solar System Exploration Virtual Institute cooperative agreement 80ARC017M0006.