MEASURING THE 21-CM GLOBAL SIGNAL FROM THE LUNAR FAR SIDE USING POLARIZATION AND TIME-DEPENDENCE. K. Tauscher\textsuperscript{1}, J. O. Burns\textsuperscript{1} and D. Rapetti\textsuperscript{2,3,1}, \textsuperscript{1}University of Colorado Boulder, \textsuperscript{2}NASA Ames Research Center, \textsuperscript{3}Universities Space Research Association.

**Introduction:** The highly redshifted 21-cm signal from neutral hydrogen is a key probe of an unobserved epoch the universe’s history, between the release of the Cosmic Microwave Background (CMB, redshift $z\approx 1100$) and the reionization of the universe ($z\approx 6$). The sky-averaged signal contains averaged information about all hydrogen in the universe. However, this signal is obscured by large galactic foregrounds. In this presentation, we lay out a pipeline designed to utilize the differences between the foreground and global signal to pull them apart from each other. The pipeline described here was built mainly for use by the Dark Ages Polarimeter PathfindER (DAPPER), a NASA-funded mission concept which avoids Earth-based systematics like the ionosphere and human-generated radio frequency interference by observing from the far side of the Moon.

**Pipeline description:** The main idea of our pipeline is to reduce overlap, or similarity, between the signal and foreground models. There are two main methods of doing this, utilizing time dependence through time-binned spectra and measuring all 4 Stokes parameters.

**Time dependence.** The fact that the global signal is spatially isotropic means that it appears in every total power (Stokes I) spectrum equally, whereas the anisotropic nature of the foreground leads it to appear in every spectrum differently. This difference in their spectra when utilizing time binned data (one spectrum that is constant with time, the other that is varying) provides a lever arm with which to effectively pull them apart.

**Full-Stokes measurements.** Since the beams used for 21-cm signal experiments are very large, anisotropies in the unpolarized foreground (as well as intrinsically polarized sources) lead to nonzero measured polarization of the foreground through antenna projection effects. On the other hand, the isotropic and unpolarized nature of the global 21-cm signal means that it does not produce a polarization response. Since the foreground appears in polarization (Stokes Q, U, and V) but the signal does not, polarization provides another way to distinguish between the two.

**Results:** Figure 1 shows a plot connecting Root-Mean-Square (RMS) uncertainty to confidence levels with and without time dependence (Drift-Scan, DS) and with and without polarization (Pol) for 5000 runs of our pipeline on simulations of signal and foreground covering the 40-120 MHz band. Clearly including time dependence yields the biggest improvement in uncertainties at any given confidence level (2-3 orders of magnitude). However, polarization measurements are necessary for a precision measurement of the signal at the noise level. This pipeline is critical for making DAPPER a successful mission.

![Figure 1: Plot showing the confidence level as a function of RMS uncertainty level with (dashed lines) and without (solid lines) time dependence (Drift-Scan, DS) and with (orange) and without (blue) polarization measurements (Pol). The largest effect comes from including time dependent spectra, but including polarization is necessary for a precision measurement near the noise level (marked by the black dotted line).](image)

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