Precision Cosmological Measurements with DARE and EDGES

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The Dark Ages Radio Explorer (DARE) is a mission concept proposed to NASA to conduct measurements of the global redshifted 21-cm hydrogen line between 40 and 120 MHz from orbit above the far side of the Moon. It is a collaboration between top universities, research centers, including the NASA Ames research center, and aerospace industry partners, led by the University of Colorado Boulder.

For the hydrogen spectral line, the frequency range 40-120 MHz corresponds to the redshift range 35-11. This is the cosmological period when the first stars, black holes, and galaxies formed, altering the temperature and ionization state of the intergalactic medium on large scales. Therefore, a precision measurement of the global signal frequency spectrum would provide critical information about the timing of these processes, as well as about key physical characteristics of the first sources. The global 21-cm signal is expected to have wideband features with absolute amplitudes of up to about 150 mK.

DARE will conduct science measurements when the spacecraft is shielded by the Moon from terrestrial radio-frequency interference and solar radiation. The lunar environment is also ideal because it eliminates the impact of the Earth's ionosphere, which corrupts low-frequency radio waves through refraction, absorption, and emission. A total of 1000 hours of science data will be measured to achieve the required statistical sensitivity of a few mK.

The DARE instrument is centered around a widefield, wideband, dual polarization, crossed-dipole antenna. Full Stokes measurements will enable to remove the intrinsic polarization of the diffuse foregrounds, which reaches up to ~ 5%. Rotation of the spacecraft about the boresight axis will be used to modulate the foregrounds and identify their isolated contribution to the measurement. Extremely accurate calibration is required to remove the instrument bandpass and minimize spectral systematics. For this reason, a full suite of calibration techniques will be conducted before launch and on-orbit. They include: 1) the bi-directional injection of pilot frequency tones to the signal chain in order to determine the receiver gain, offset, and the impedance match between the receiver and the antenna, and 2) the determination of the antenna beam to better than -45 dB through a combination of simulations, anechoic chamber measurements, and on-flight mapping using a high-power calibration source from the Earth.

The talk will also provide an update of the Experiment to Detect the Global EoR Signature (EDGES), which is attempting to detect the global 21-cm signal from the Murchison Radio-astronomy Observatory (MRO) in Western Australia.