

## Recent Developments on the EIGSEP Experiment for 21-cm Global Signal Detection

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Measurements of the redshifted 21-cm line offer a direct probe of the Cosmic Dawn, when the first stars and galaxies formed. This period of cosmic history is largely unconstrained, but is accessible through measurements of the global—that is, all-sky averaged—brightness temperature of the 21-cm radiation. At the early stages of Cosmic Dawn, Lyman-alpha photons from the first generation of stars couple the 21-cm spin temperature to the kinetic temperature of the hydrogen gas, which imprints an absorption feature relative to the CMB temperature in the global 21-cm spectrum. X-ray radiation heats the hydrogen gas and drives the 21-cm spin temperature to the CMB temperature, and possibly produces an emission feature, before UV-radiation reionizes the hydrogen and extinguishes the signal. The shape of this spectrum—and in particular the center, width, and depth of the absorption profile—thus probes astrophysical parameters related to the star formation rate, x-ray heating and production of Ly-alpha and ionizing photons.

The 21-cm signal from Cosmic Dawn and Epoch of Reionization is redshifted to frequencies below 250 MHz. At these frequencies, foreground emission, in particular galactic synchrotron emission, are 4-5 orders of magnitude brighter than the global 21-cm signal. Separating the foregrounds from the cosmological signal is the primary obstacle for global 21-cm experiments. In principle, the foregrounds can be separated from the 21-cm signal using their spectral smoothness, since the foregrounds are expected to be power-law like while the 21-cm spectrum is expected to have multiple turning points. However, instrumental effects like antenna beam chromaticity, impedance mismatch between the antenna and receiver, scattering off soil or ground planes, and cable reflections, introduce spectral shapes in the data that tend to mix the spectral modes of the 21-cm signal and the foregrounds.

The Electromagnetically Isolated Global Signal Estimation Platform (EIGSEP) is a global signal experiment being developed in the Radio Astronomy Laboratory at UC Berkeley. EIGSEP is designed to facilitate the careful calibration needed to extract the 21-cm signal. In particular, EIGSEP uses an elevated antenna platform about 100 meters off the ground to create a zone around the antenna free of conductive elements. This novel design means that interference due to radio waves scattering off metal or galvanic soil layers appears at different spectral scales than the expected 21-cm signal and can thus be filtered. In the delay-space formalism, scattered waves appear at much larger delays than for typical antennas placed on the ground, hence creating very fast ripples in the spectra that can be filtered with a low-pass filter. EIGSEP also uses two auxiliary antennas placed on the ground that are correlated with the elevated antenna for calibration, noise estimation, and flagging of radio frequency interference. The three antennas are dual-polarization and correlated over the frequency range 50-250 MHz.

EIGSEP was first deployed in a canyon in Western Utah in October of 2023, and then again in July and October of 2024. The first deployment was solely on the ground and was primarily used for system testing and RFI measurements. During the subsequent deployments, one antenna was suspended in the canyon. I will describe the recent progress of the EIGSEP experiment, including details from the first three deployments and our work on calibration, RFI flagging, and mechanical design. Additionally, I will discuss some of the unique challenges and potentials of an elevated platform, including terrain modeling, in-situ beam measurements, and foreground rejection.