32nd URSI GASS, Montreal, 19–26 August 2017

The Hydrogen Epoch of Reionization Array (HERA)

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The Hydrogen Epoch of Reionization Array (HERA) uses the unique properties of the 21 cm line of neutral hydrogen to probe the Epoch of Reionization (EoR) and the preceding Cosmic Dawn. During these epochs, roughly 0.3 to 1 Gyr after the Big Bang, the first stars and black holes heated and reionized the Universe. By directly observing the large scale structure of reionization as it evolves with time, HERA will profoundly impact our understanding of the birth of the first galaxies and black holes, their influence on the intergalactic medium (IGM), and cosmology. Located on the SKA South African site and addressing primary science, HERA is an SKA Precursor instrument.

HERA was ranked the "*top priority in the Radio, Millimeter, and Sub-millimeter category of recommended new facilities for mid-scale funding*" by the Decadal Survey and has been pursued aggressively over the last five years. Using the Donald C. Backer Precision Array to Probe the Epoch of Reionization (PAPER), the Murchison Widefield Array (MWA), and the MIT EoR experiment (MITEoR), the strong foregrounds masking the 21 cm signal have been characterized and powerful techniques for overcoming them in power spectral measurements of reionization have been developed. These techniques are being further developed with the HERA prototype — a 19-element array of 14 m parabolic dishes in the South African Karoo Radio Astronomy Reserve. Construction is on-going for the next 18 to bring the total to 37 elements, a size that will start to have the potential to detect the EoR signal. Funds have been obtained to build the array to 240 elements. The full complement is expected to be 350 elements, with 320 in a compact core (see Fig. 1).

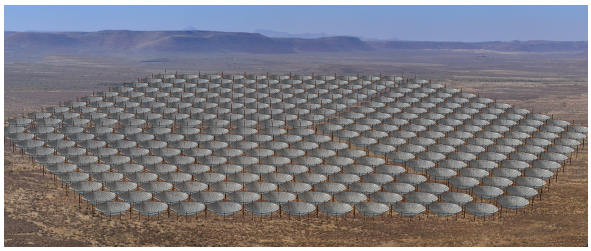

Figure 1. Rendering of the completed 320-element core of HERA.

This array is an optimized 21 cm cosmology machine capable of high SNR measurements of the 21 cm power spectrum at redshifts $z = 6$ to 13 (*Planck* data suggest $z \approx 9$ for instantaneous reionization). These measurements are uniquely capable of characterizing the evolution of the cosmic ionization field, exposing the nature of the first ionizing sources and tracking the growth of structures in the "cosmic web." In combination with other probes of our early universe, HERA provides a comprehensive picture of reionization and breaks measurement degeneracies in fundamental cosmological parameters. HERA also advances the interests of the broader astronomical community by providing data cubes for cross-correlating with other high-redshift probes (e.g. JWST; CMB maps; CO, CII, and Ly$-\alpha$ intensity mapping), releasing deep multi-frequency imaging surveys for galactic and extra-galactic science, and acting as a hardware platform for other timely science instruments targeting, e.g., 21 cm tomography of the pre-reionization epoch, fast radio bursts, and auroral emission from exoplanets.