The Dark Ages Lunar Interferometer (DALI)

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International Union of Radio Science (URSI) General Assembly,
Chicago, IL; 2008 August 10–16

Abstract

The Dark Ages represent the last frontier in cosmology, the era between the genesis of the cosmic microwave background (CMB) at recombination and the formation of the first stars. During the Dark Ages, when the Universe was unlit by any star, the only detectable signal is likely to be that from neutral hydrogen (H I), which will appear in absorption against the CMB. The H I absorption represents potentially the richest of all data sets in cosmology—not only is the underlying physics relatively simple so that the H I absorption can be used to constrain fundamental cosmological parameters in a manner similar to that of CMB observations, but the spectral nature of the signal allows the evolution of the Universe as a function of redshift (z) to be followed. The H I absorption occurs in dark matter-dominated overdensities, locations that will later become the birthplaces of the first stars, so tracing this evolution will provide crucial insights into the properties of dark matter and potentially reveal aspects of cosmic inflation. Moreover, given the relatively simple physics—the Universal expansion, Compton scattering between CMB photons and residual electrons, and gravity—any deviation from the expected evolution would be a "clean" signature of fundamentally new physics.

The Dark Ages Lunar Interferometer (DALI) is a mission proposed for study to NASA for a telescope located on the far side of the Moon,

the only site in the solar system shielded from human-generated interference and, at night, from solar radio emissions. The DALI array will observe at 3–30 m wavelengths (10–100 MHz; redshifts $15 \le z \le 150$), and the DALI baseline concept builds on ground-based telescopes operating at similar wavelengths, e.g., the Long Wavelength Array (LWA) and Murchison Widefield Array (MWA). Specifically, the fundamental collecting element will be dipoles. The dipoles will be grouped into "stations," deployed via rovers over an area of approximately 50 km in diameter to obtain the requisite angular resolution. The desired three-dimensional imaging requires approximately 1000 stations, each containing 100 dipoles (i.e., $\sim 10^5$ dipoles); alternate processing approaches may produce useful results with significantly fewer dipoles (factor $\sim$ 3–10). Each station would be deployed by one rover, which would also serve as a "transmission hub" for sending the signals for correlation to a central processing facility. After sending the correlator output to Earth, analysis would then proceed via standard methods being developed for ground-based arrays.