The Dark Ages Lunar Interferometer (DALI)

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Abstract

The Dark Ages Lunar Interferometer (DALI) is a Moon-based radio telescope concept aimed at imaging highly-redshifted neutral hydrogen signals from the first large scale structures forming during the Universe's "Dark Ages" and "Epoch of Reionization."

In the standard hot Big Bang cosmology, the Universe started in an initially dense ionized state. As it expanded and cooled, it underwent a transition to a largely neutral state at the time of recombination. After recombination, baryons were able to collapse into overdense regions. The Universe's *Dark Ages* consist of this interval after recombination, when the Universe was unlit by any stars. As the H I gas accumulated in overdense regions, its excitation temperature decoupled from, and became lower than, the temperature of the cosmic microwave background (CMB). Observations of the highly-redshifted hyperfine (21-cm) transition should show a patchwork of absorption features from the first large-scale structures against the CMB. Importantly, observing these features would probe structure formation in the relatively simple *linear regime*. Later, at redshifts of 6–10, the first stars and black holes formed in these overdense regions, and their collective UV radiation led to the Universe becoming nearly fully ionized, a state in which it remains today. The *Epoch of Reionization* (EoR) marks this second transition, during which time the 21-cm line excitation temperature should have risen, eventually exceeding the CMB temperature, until essentially all of the hydrogen was ionized. Imaging the (redshifted) 21-cm line of H I at different wavelengths will construct a *tomographic* or 3-dimensional view of the Dark Ages and EoR.

As a secondary science goal, DALI will target auroral radio bursts from extrasolar planets in order to study their magnetospheres, potentially helping to distinguish habitable and non-habitable terrestrial-mass planets in the solar neighborhood.

Operating at 1–30 meter wavelengths (10–300 MHz), probing redshifts $6 \lesssim z \lesssim 100$, DALI would be located on the far side of the Moon, where it would be shielded from terrestrial emissions and, for half of the Moon's orbit, from solar radio emissions. In order to have sufficient sensitivity, the array must have an effective collecting area of at least 10 km^2 (10^7 m^2).

We describe the notional DALI concept and identify areas of technology development that will be required over the next decade that would allow the deployment of DALI in following decades.