Searching for exotic physics and investigating the first stars with the 21-cm signal measured from lunar orbit.
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One of the ways to investigate the first billion years of the universe, which are often obscured from current view, is to observe the sky-averaged (global), highly redshifted 21-cm line of neutral hydrogen. Since the line has a definite frequency, the redshift of neutral hydrogen directly determines the frequency at which its 21-cm line is observed; so the global signal can be read as a history of the universe's neutral hydrogen. In 2018, the EDGES collaboration reported a broad, deep absorption trough centered at 78 MHz in their sky-averaged radio data. This frequency corresponds to Cosmic Dawn, when stars were first forming, and could imply the presence of an unexpectedly strong radio background or colder hydrogen than is possible from adiabatic cooling. However, the result is model-dependent and we argue that their data can also be explained by defects in the antenna's ground plane. Since a ground plane is necessary for Earth-based experiments, measurements from space would provide the most rigorous verification of the reported trough. Another key driver of a space-based experiment is the contamination of Earth-based data by Radio Frequency Interference (RFI). We are working on a NASA-funded space-based mission concept known as the Dark Ages Polarimeter PathfindER (DAPPER) which will orbit the moon, taking data above the lunar farside so as to avoid the RFI from Earth. With its dual thin wire dipole antennas with no ground screen, DAPPER will see the 21-cm signal with very different systematic effects than EDGES. In addition to sparse sampling of the EDGES band, DAPPER will provide continuous frequency coverage from 17 to 38 MHz, giving insight into the universe's as-yet unexplored Dark Ages at redshifts 36-83 when there were no stars. If extra cooling suggested by EDGES is present during Cosmic Dawn, then the feature in the Dark Ages will also be amplified, making it visible to DAPPER. I will present simulated end-to-end DAPPER results, including input signals consistent with EDGES and those consistent with the standard Lambda-CDM cosmological model.

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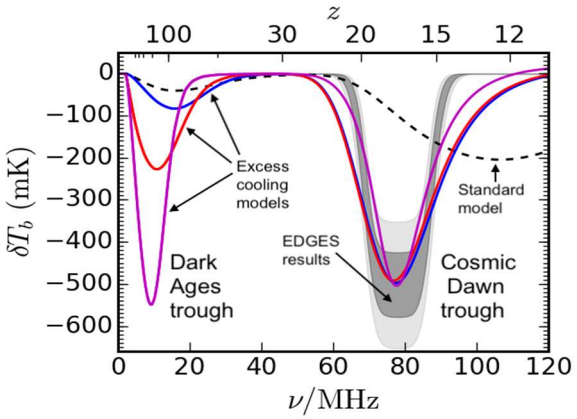

Fig. 1: Summary of the inspiration for DAPPER. The gray bands show EDGES reported errors while the solid colored lines show three extra cooling models consistent with the EDGES result in the Cosmic Dawn regime (10<z<30) that differ from each other in the Dark Ages regime (z>30). DAPPER could help distinguish between these models or, alternatively, could confirm the standard model shown by the dashed black line.