OBSERVING THE DARK AGES OF THE EARLY UNIVERSE FROM THE FARSIDE OF THE MOON.

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The results of a NASA-funded Astrophysics SmallSat concept study for a lunar-orbiting experiment, the Dark Ages Polarimeter PathfindER (DAPPER), that is designed to observe the unexplored Dark Ages epoch of the early Universe will be presented. The Dark Ages, probed by the highly redshifted 21-cm neutral hydrogen global signal, is the ideal epoch for a new rigorous test of the standard ΛCDM cosmological model. DAPPER will search for divergences from the standard model that will indicate new physics such as heating or cooling produced by dark matter.

A broad absorption trough in the redshifted 21-cm spectrum is expected during the Dark Ages, prior to the formation of the first stars and thus determined entirely by cosmological phenomena. DAPPER will observe this pristine epoch (17-38 MHz; z~83-36), and will measure the amplitude of the 21-cm spectrum to the level required to distinguish (at $>5\sigma$) the standard cosmological model from that of additional cooling derived from recent ground-based EDGES results.

The main challenge of this measurement is the removal of bright foregrounds from the Milky Way. DAPPER is designed to overcome this by utilizing two pioneering techniques: (1) a polarimeter to measure polarization induced by the anisotropic foregrounds and large antenna beam to aid in the separation of the foregrounds from the isotropic, unpolarized global signal, and (2) a pattern recognition analysis pipeline based on well-characterized training sets of foregrounds from sky observations, instrument systematics from simulations and laboratory measurements, and signals from theoretical predictions. End-to-end simulations of the DAPPER instrument including thermal noise, systematics from the spectrometer/polarimeter and the beam-averaged foreground, along with 21-cm models which include added cooling meet our sensitivity requirements to separate the standard cosmological models from ones that point toward new physics.

DAPPER's science instrument consists of dual orthogonal dipole antennas and a tone-injection receiver based on high TRL components from the Parker Solar Probe/FIELDS, THEMIS, and the Van Allen Probes. DAPPER will be deployed into a frozen 50×125 km lunar orbit to provide 4615 hours of radio-quiet integration over a 26.4 month lifetime.

This study was supported by NASA cooperative agreement 80NSSC19K0141 and the NASA Solar System Exploration Research Virtual Institute cooperative agreement 80ARC017M0006.

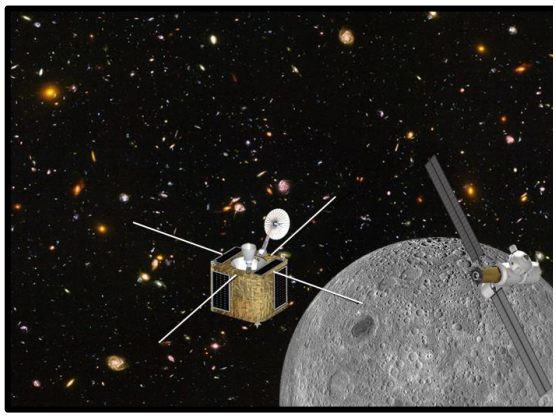

Figure 1. DAPPER is a SmallSat that will be initially deployed in the vicinity of the lunar Gateway and then descend to a 50×125 km frozen lunar orbit. It will collect redshifted 21-cm global signal data when it is above the radio-quiet farside of the Moon. The 21-cm spectrum from neutral hydrogen will yield information about possible added cooling of baryons via scattering by dark matter.