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HADES: A SMALLSAT MISSION TO CHARACTERIZE RADIO FOREGROUNDS IN THE LUNAR ENVIRONMENT

Abstract

The goal of the proposed HI Absorption in the Dark agES (HADES) mission is to provide key measurements of radio frequency foregrounds in the range of 1-100 MHz from the far side of the moon. These observations are a necessary step towards employing sky-averaged intensity measurements of the 21 cm line of neutral hydrogen (HI) against the cosmic microwave background radiation to constrain the timing of the first sources of light and probing fundamental processes leading to early structure formation in the Universe. The far side of the moon is potentially the most pristine location in the inner solar system to conduct such observations for multiple reasons: 1) Earth's ionosphere has a finite plasma frequency that distorts and reflects signals < 30 MHz making these observations impossible from ground. 2) The lunar disk acts as a natural shield against any radio transmissions from Earth and Sun creating an incredibly clean RFI environment.

The HADES mission concept was developed by a team of early-career researchers and students as part of the first Smallsat Mission Design School organized by Cornell University over Summer 2021. We propose to conduct low-frequency (1-100 MHz) observations through a 12U CubeSat positioned in lunar orbit, nominally at 50 km altitude, to measure the brightness temperature of astrophysical foregrounds. Using these observations, we will verify and provide feedback to theoretical predictions of the radio frequency environment in lunar orbit and on the far side of the Moon. We will discuss science traceability defining mission requirements, engineering requirement for the spacecraft platform including both instruments and subsystems and an overall design that fits within the NASA Pioneers flight opportunity. As the Pioneers call does not offer a rideshare opportunity to lunar orbit, a key requirement of this mission is the definition of a novel GTO to Lunar orbit transfer trajectory enabled by an onboard electric propulsion system. GTO to lunar orbit maneuvering has not been attempted before in a 12U Cubesat and would be a novel technological milestone. The measurements taken by this mission would be critical to inform instrumentation and observation planning choices for future flagship missions, as well as the potential location of a future radio observatory on the surface of the moon.