IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

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DETECTION OF THE REDSHIFTED 21-CM RADIATION LINE: A MISSION CONCEPT STUDY FOR THE ESTABLISHMENT OF A LUNAR RADIO TELESCOPE ARRAY IN THE SCHRÖDINGER BASIN

Abstract

The detection of neutral hydrogen atoms found in the interstellar medium enables the understanding of early structures formation during the cosmic dawn and Epoch of Reionization in the history of the Universe. The 21-cm hyperfine line enables the detection of such hydrogen atoms, but being a very low frequency detection method, it is susceptible to atmospheric absorption and solar irradiation. This makes a near-polar location on the far side of the Moon an excellent landing site candidate for performing such a study.

Based on the current framework of the Global Exploration Roadmap (GER), this paper highlights a mission design to deploy radio telescopes on the Lunar surface, shielded from radio frequency interference - the Lunar Radio Telescope Array (LRTA). Located near the south polar end of the South Pole-Aitken basin, the Schrödinger basin (approx. 320 km in diameter) is selected as the landing site, considering its impact history and the crater's geology for robotics navigation. It's also a major point of interest based on current space agencies' mission architecture design.

The maturity of science objectives, in particular Lunar radio telescope technologies and the Lunar Platform Orbital-Gateway (LOP-G) mission architecture, are also considered in this study. The LOP-G will be advantageous for telerobotics operations and act as a communication relay for the Earth-Moon system. This strategic configuration is also supplemented by making use of in-development infrastructures and space systems arising from the HERACLES framework (Landgraf et al. 2015).

The proposed radio telescope incorporates the placement of thin space-grade polyimide films on which multiple dipole antennas are installed (Lazio et al. 2009). By being both volume- and mass-efficient, this facilitates their transportation as cargo onboard launch vehicles, such as Falcon Heavy or Delta IV Heavy. Additionally, this allows for an easy deployment by rovers, thus enabling the use of autonomous capabilities.

The dexterous and traverse capacities of robotics assets are also studied in the design concept to better characterize the configuration of radio telescopes. Furthermore, the lunar dust environment poses significant challenges stemming from insufficient knowledge, such as the electrical properties of regolith at the site of the Lunar radio array. The results of this paper will seek to establish a mission architecture in tandem with technology readiness levels (TRL), while highlighting potential solutions to challenges that may arise along the way.

Keywords: Low Frequency Radio Astronomy, Lunar Radio Telescope Array, HERACLES, Global Exploration Roadmap