Engagement Opportunities in NASA STEM 2023 (EONS-2023)
NASA Research Announcement (NRA)
MUREP Space Technology Artemis Research (M-STAR)
Number: NNH23ZHA001N-MSTAR

Title: Constraining Exospheric Water Using Mid-IR Sensing and LIBS for Lunar Rover Missions

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City/State: Dover, Delaware

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Summary: Our understanding of water cycles on the Moon has significantly enhanced recent observations by Chang E-5, Lunar Prospector, and Chandrayaan-1 missions indicating the existence of an active water cycle on the Moon. At Delaware State University (DSU), we propose establishing an MSTAR program driven by integrated research, education, and innovation. The DSU-MSTAR program will advance fundamental knowledge and technology for NASA's landed ARTEMIS lunar rover mission. We propose to develop a lunar rover payload with integrated water vapor and Laser-induced breakdown spectroscopy (LIBS) instruments to simultaneously detect and correlate water isotopes with characteristics elemental composition of lunar regolith.

Technical development and research impact: DSU, a Historically Black University, prides itself in its proven excellence in teaching and research. It enrolls a diverse population of students (~5000) traditionally underrepresented in STEM disciplines. For several years, DSU has established itself at the forefront of optics and photonics research that transcends multidisciplinary fields of earth sciences, environmental, defense, and biomedical sensing applications. To advance research in lunar missions, DSU-MSTAR will forge new collaborations with NASA GSFC in the development of low-mass and low-power lunar rover payloads. The proposed technology is based on the simultaneous detection of water (H16OH) and isotopes (H16OD) in the (6700 nm) mid-infrared region using a closed path in compact Herriot cell optical design and wavelength modulation spectroscopy. The LIBS payload will simultaneously sample lunar regolith. We seek to address the following science questions, (1) how does the isotopic water concentration on the lunar surface reveal information about its age and depth and other volatiles in the exosphere? (2) how does the elemental composition of lunar regolith and rocks determine the retention of water content? Due to the airless atmosphere of the Moon, we will utilize Artificial intelligence (AI) and Machine learning (ML) approaches to discriminate spectral interference with instrument drifts and correlate mid-IR trace gas profile with LIBS spectral information. DSU-MSTARs proposed effort starts at a TRL-1 and, after three years, develops as a TRL-4 with a lab-tested prototype mid-IR LIBS system.

NASA Relevance and STEM Engagement: DSU MSTAR will advance new knowledge, which aligns with STMD priority areas to Explore Transformative Missions and Discoveries with

highly sensitive and exploratory instrumentation Capabilities. The research will develop vehicle platform technologies supporting discoveries and enabling long-duration human exploration missions. In this process, DSU MSTAR will initiate a STEM engagement space program, e.g., Lander and CubeSat payload technology development for students and the next-generation NASA workforce for future lunar and Mars missions.