Paper ID: 96931
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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

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ACTIVE NEUTRON IMAGING EXPERIMENTS AND SIMULATIONS FOR MAPPING LUNAR SUBSURFACE WATER AND GEOCHEMISTRY

Abstract

Identifying and characterizing buried lunar ice is essential for reconstructing the Moon's volatile history, improving models of lunar water deposition and retention, and assessing the feasibility of in-situ resource utilization. Lunar water ice deposits provide insights into impact-driven volatile delivery, solar wind interactions, and potential endogenic sources. Additionally, constraining the distribution and stability of these deposits at depth is critical for planning future robotic and crewed missions. We present our experimental and modeling efforts toward developing an active neutron imaging system for detecting and mapping subsurface hydrogen on the Moon and other planetary bodies. This technique combines a neutron and gamma-ray spectrometer (GRNS) with Associated Particle Imaging (API) to quantify hydrogen abundance (at levels of hundreds of ppm to several wt.Our experimental setup at Lawrence Berkeley National Laboratory includes a 14.1 MeV fast neutron generator along with neutron, gamma-ray, and alpha detectors integrated into the API system. Measurements involve irradiating high-density polyethylene and lunar regolith simulants with fast neutrons and detecting scattered neutrons to infer hydrogen abundance and location. We evaluated the performance of various scintillator technologies for hydrogen detection by measuring neutron scattering in different polyethylene-regolith configurations. Initial results indicate that fast neutron scattering is effective for detecting buried water ice within the top 5–10 cm of the surface. However, ongoing modeling efforts aim to quantify hydrogen contributions from other elements and improve depth resolution. These results highlight the potential of API-GRNS for subsurface hydrogen mapping and resource detection. Future work will focus on enhancing imaging resolution, optimizing detector materials, and advancing neutron-based hydrogen detection techniques for upcoming lunar missions.