Exploration of resources in permanently shadowed lunar polar regions

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Our understanding of the lunar dust exosphere is based on NASA’s Lunar Atmosphere and Dust Environment Explorer. Its findings provide a unique opportunity to map the composition of the lunar surface from orbit and identify regions that are rich in volatiles, providing opportunities for future in situ resource utilization (ISRU), which is a key element in establishing human habitats on the Moon. The expected availability of water ice, and other volatiles, in Permanently Shadowed Regions (PSR) makes the lunar poles of prime interest. However, the relative strength of the various sources, sinks, and transport mechanisms of water into and out of PSRs remain largely unknown. The quantitative characterization of the temporal and spatial variability of the influx of IDPs to the polar regions of the Moon is critical to the understanding of the evolution of volatiles in PSRs. A dust instrument onboard a polar orbiting lunar spacecraft could make fundamental measurements to assess the availability and accessibility of water ice in PSRs. Water is thought to be continually delivered to the Moon through geological timescales by water-bearing comets and asteroids and produced continuously in situ by the impacts of solar wind protons of oxygen-rich minerals on the surface. IDPs are an unlikely source of water due to their long UV exposure in the inner solar system, but their high-speed impacts can mobilize secondary ejecta dust particles, atoms and molecules, some with high-enough speed to escape the Moon. Other surface processes that can lead to mobilization, transport and loss of water molecules and other volatiles include solar heating, photochemical processes, and solar wind sputtering. Since the efficiency of these are reduced in PSRs, dust impacts remain the dominant process to dictate the evolution of volatiles in PSRs.

The continually present dust ejecta cloud was observed by LADEE/LDEX. A more capable dust instrument, in addition to the size and speed of an impacting particle, can also measure the composition of secondary ejecta particles, resulting in a surface composition map with a spatial resolution comparable to the height of the spacecraft.

This talk will describe the available instrumentation, its testing and calibration using the SSERVI/IMPACT dust accelerator facility at the University of Colorado, Boulder, and conclude with the recognition that a polar-orbiting spacecraft could directly sample lunar ejecta, providing the critical link between IDP bombardment and the evolution of water ice in PSRs.