SCIENCE OPPORTUNITIES FOR LUNAR RETRO-REFLECTORS.

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Introduction: Lunar retroreflector arrays (LRAs) consisting of corner-cube reflectors (CCRs) placed on the nearside of the Moon from the Apollo-era missions have demonstrated their longevity, cost-effectiveness, ease of deployment, and most importantly their interdisciplinary scientific impact through the ongoing lunar laser ranging (LLR) experiment. The human exploration of the Moon, and the lunar south polar region in particular, provides a unique opportunity to build on this legacy and contribute to the scientific return of Artemis, for many decades to come.

Motivation: The lunar south polar region is home to one of the coldest regions in the solar system, offering a unique opportunity to impact the LLR experiment. A retroreflector placed at an Earth-visible cold region will lift the thermally-limited size constraint on a single CCR. A *large* single CCR placed in such cold regions would benefit from a significant throughput gain, potentially enabling the extension of the LLR Earth station network (currently 4) to the wider SLR network (45+ stations distributed globally) [1].

Scientific impact: Currently, LLR is the only observation that allows an estimation of the shape of the lunar core. LLR-derived lunar interior and core shape parameters improve our understanding of the lunar formation and evolution. While the degree-2 order-0 shape of the lunar core-mantle boundary is accessible using LLR analysis, the degree-2 order-2 shape remains unresolved and holds importance to lunar dynamo mechanisms through tidal instabilities [2].

Recent work [3] shows that new retroreflectors at the south pole and the limbs, would help resolve this parameter through its improved geometry. Currently, lunar ephemeris fitted to LLR data provides the link that connects the lunar principal axes frame to the solar system barycentric frame. A well-known lunar frame attached to the lunar crust has the potential to confirm the existence of a solid inner core through resonances [4] and contributes to the maintenance of precise solar system ephemerides [5,6] that aid high-precision navigation. New retroreflectors would have a significant positive impact on LLR-derived science that span lunar science [7], Earth orientation and rotation, reference frames [8] and precision tests of fundamental physics [6,9].

NASA's Commercial Lunar Payload Delivery Services (CLPS) program and the Lunar Geophysical Network (LGN) mission [10] are expected to be the primary drivers for near-future lunar surface deployments of retroreflectors.

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