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Lunar Laser Ranging Experiment for Japanese SELENE-2 landing mission

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We present the development status of the Lunar Laser Ranging experiment proposed to Japanese SELENE-2 lunar landing mission. The Lunar Laser Ranging measures the distance between laser link stations on the Earth and retroreflectors on the Moon, by detecting the time of flight of photons of high-powered laser emitted from the ground station. Since the Earth-Moon distance contains information of lunar orbit, lunar solid tides, and lunar orientation and rotation, we can estimate the inner structure of the Moon through orientation, rotation and tide.
Retroreflectors put by the Apollo and Luna missions in 1970's are arrays of many small Corner Cube Prisms (CCP). Because of the tilt of these arrays from the Earth direction due to the optical libration, the returned laser pulse is broaden, causing the main range error of more than 1.5 cm ([1]). Therefore retroreflectors with larger single aperture are necessary for more accurate ranging, and we propose a large single retroreflector of hollow-type with 15 cm aperture. Larger aperture up to 20 cm might be favorable if more mass is permitted for payloads.
To cancel the velocity aberration, a large, single aperture retroreflector needs small amount of offset angle between the reflecting planes to spoil the return beam pattern. This angle offset, called Dihedral Angle Offset (DAO) must be optimized to be less than 1 second of arc with 0.1 seconds of arc accuracy to accumulate more photons [2, 3]. The realization of such small DAO is challenging with current technology, therefore the development of fabrication method is important.
As for the mirror material, some ceramic products (ZPF: Zero-expansion Pore-free ceramics or SiC: silicon carbide) are under consideration in terms of weight, hardness and handling. The thermal quality of the material can be evaluated by both the thermal conductivity and the coefficient of thermal expansion. The method to fasten three planes each other with precise DAO must be developed.

References: [1] Murphy T. et al. (2008) PAPS, 120, 20-37. [2] Otsubo T. et al. (2010) Adv. Space Res., 45, 733-740. [3] Otsubo T. et al. (2011) Earth Planet Space, 63, e13-e16.