Return to the Moon (02)
Scientific Highlights and Lessons from Recent Lunar Missions (1)

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MOONLIGHT: A LUNAR LASER RANGING RETROREFLECTOR ARRAY FOR THE 21ST CENTURY

Abstract

Since the 1970s Lunar Laser Ranging (LLR) to the Apollo Cube Corner Retroreflector (CCR) Arrays

(developed by the University of Maryland, UMD) supplied almost all significant tests of General Relativity: possible changes in the gravitational constant, gravitational self-energy, weak equivalence principle, geodetic precession, inverse-square force-law. LLR has also provided significant information on the composition and origin of the moon. This is the only Apollo experiment still in operation. In the 1970s Apollo LLR Arrays contributed a negligible fraction of the ranging error budget. Since the ranging capabilities of ground stations improved by more than two orders of magnitude, now, because of the lunar librations, Apollo CCR arrays dominate the error budget. With the MoonLIGHT INFN project, in 2006 INFN-LNF joined UMD in the development and test of a new-generation LLR payload made by a single, large CCR (100 mm diameter) unaffected by the effect of librations. In particular, INFN-LNF built and is operating a new experimental apparatus (Satellite/lunar laser ranging Characterization Facility, SCF) and created a new industry-standard test procedure (SCF-Test) to characterize and model the detailed thermal behavior and the optical performance of CCRs in accurately laboratory-simulated space conditions, for industrial and scientific applications. Our key experimental innovation is the concurrent measurement and modeling of the optical Far Field Diffraction Pattern (FFDP) and the temperature distribution of retroreflector payloads under thermal conditions produced with a close-match solar simulator. The apparatus includes infrared cameras for non-invasive thermometry, thermal control and real-time payload movement to simulate satellite orientation on orbit with respect to solar illumination and laser interrogation beams. These capabilities provide: unique pre-launch performance validation of the space segment of LLR/SLR (Satellite Laser Ranging); retroreflector design optimization to maximize ranging efficiency and signal-to-noise conditions in daylight. Results of the SCF-Test of our CCR payload will be presented. Negotiations are underway to propose our payload and SCF-Test services for precision gravity and lunar science measurements with next robotic lunar landing missions. We will describe the addition of the CCR optical Wavefront Fizeau Interferogram (WFI) concurrently to FFDP/temperature measurements in the framework of an ASI-INFN project, ETRUSCO-2. The main goals of the latter are: development of a standard GNSS laser Retroreflector Array; a second SCF; SCF-Test of Galileo, GPS and other 'as-built' GNSS retroreflector payloads. Results on analysis of Apollo LLR data and search of new gravitational physics with LLR, Mercury Radar Ranging, SLR of LAGEOS (Laser GEOdynamics Satellite) will be presented