International, private-public, multi-mission, next-generation lunar laser retroreflectors

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Since the 1970s Lunar Laser Ranging (LLR) to the Apollo/Lunokhod Cube Corner Retroreflector (CCR) arrays supplied some of the best tests of General Relativity (GR): possible changes in the gravitational constant, weak and strong equivalence principle, gravitational self-energy (PPN parameter beta), geodetic precession, inverse-square force-law [1][2]. LLR has also provided significant information on the composition of the deep interior of the Moon [3]. LLR physics analysis also allows for constraints on extensions of GR (like spacetime torsion [4]) and on new gravitational physics that may explain the gravitational universe without Dark Matter and Dark Energy (like Non-Minimally Coupled gravity [5]). LLR is the only Apollo/Lunokhod experiment still in operation. In the 1970s LLR arrays contributed a negligible fraction of the ranging error budget. Since the capabilities of ground stations of the International Laser Ranging Service (in particular APOLLO in USA) improved by more than two orders of magnitude, now, because of the lunar librations, current CCR arrays dominate the error. With the US/Italy project LLRRA21/MoonLIGHT (Lunar Laser Ranging Retroreflector Array for the 21st century/Moon Laser Instrumentation for General relativity High accuracy Tests) UMD (Univ. of Maryland) and INFN (Italian National Institute for Nuclear Physics) developed a new-generation LLR payload made by a single, large CCR (100 mm diameter), unaffected by the effect of librations, that will improve the LLR accuracy by a factor of ten to one hundred. The performance of this 'big CCR' is being characterized at the SCF_Lab test facility at INFN-LNF, Frascati, Italy [6]. INFN also developed INRRI (INstrument for landing-Roving laser Retroreflector Investigations), a microreflector payload for the lunar surface to be laser-ranged by orbiters [7]. This will further extend the physics and lunar science reach of LLR. INRRI can also provide positioning services on the far side (it is proposed for CNSA's Chang'E-4 mission). INRRI has been embarked on ESA's ExoMars lander "Schiaparelli" and it has been requested by NASA to ASI for the Mars 2020 Rover mission. LLR data are analized/simulated with the Planetary Ephemeris Program developed by CfA. INFN, UMD and MEI signed a private-public partnership, multi-mission agreement to deploy the big and the microreflectors on the Moon. Through existing MoUs between INFN and the Russian Academy of Sciences, international negotiations are also underway to propose the new lunar reflectors and the SCF_Lab services for the next robotic missions of the Russian space program.

References:

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