Lunar, Cislunar, Near/Farside Laser Retroreflectors for the Accurate: Positioning of Landers/Rovers/Hoppers/Orbiters, Commercial Georeferencing, Test of Relativistic Gravity and Metrics of the Lunar Interior


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Abstract: Since 1969 Lunar Laser Ranging (LLR) to Apollo/Lunokhod laser retroreflector (CCR) arrays supplied accurate tests of General Relativity and new gravitational physics: possible changes of the gravitational constant Gdot/G, weak and strong equivalence principle, gravitational self-energy (PPN parameter beta), geodetic precession, inverse-square force-law [1][2][3]; it also allows constraints gravitomagnetism. Some of these measurements also allowed for testing extensions of General Relativity, including spacetime torsion, non-minimally coupled gravity (that may explain the gravitational universe without dark matter and dark energy)[4]; in principle, although technically and programmatically very challenging, also effective quantum gravity exploiting the L1 lagrangian point. LLR also provided, and will continue to provide, significant information on the composition of the deep interior of the Moon, complementary to the GRAIL mission of NASA. LLR first provided evidence of the existence of a fluid component of the deep lunar interior, confirmed also by lunar seismometry data [1].

In 1969 CCR arrays contributed a negligible fraction of LLR error. Since laser stations improved by >100, now, because of lunar librations, current arrays dominate the error. We developed a next-generation single large CCR, MoonLIGHT-NGR¹ unaffected by librations that supports an improvement of the space segment of the LLR accuracy up to x100. INFN also developed INRRI (INstrument for landing-Roving laser Retroreflector Investigations), a microreflector to be laser-ranged by orbiters. MoonLIGHT/INRRI, characterized at SCF-Lab [5] of INFN-LNF, Italy, for their deployment on the lunar surface or the cislunar space, will accurately position landers-rovers-hoppers-rovers of GLXP/agency missions, thanks to LLR observations from select ground station of the Interna-

1 Moon Laser Instrumentation for General relativity high-accuracy test - Next Generation Retroreflector.