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International, private-public, multi-mission, next-generation Lunar/Martian laser retroreflectors

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Abstract

We describe an international, private-public, multi-mission effort to deploy on the Moon next-generation lunar laser retroreflectors to extend (also to the far side) the existing passive Lunar Geophysical Network (LNG) consisting of the three Apollo and the two Lunokhod payloads. We also describe important applications and extension of this program to Mars Geophysical Network (MGN).

1. Goals and Opportunities

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. LLR has also provided significant information on the composition of the deep interior of the Moon. LLR physics analysis also allows for constraints on extensions of GR (like spacetime torsion) and on new gravitational physics that may explain the gravitational universe without Dark Matter and Dark Energy (like Non-Minimally Coupled gravity). 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, Grasse in France and MLRO in Italy) improved by more than two orders of magnitude, now, because of the lunar librations, current CCR arrays dominate the error.

With the Italy/US project MoonLIGHT/LLRRA21 (Moon Laser Instrumentation for General relativity High accuracy Tests/Lunar Laser Retroreflector Array for the 21st Century) INFN (Italian National Institute for Nuclear Physics) and UMD (Univ. of Maryland) 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. INFN also developed INRRI (INstrument for landing-Roving laser Retroreflector Investigations), a microreflector payload for the lunar surface to be laser-ranged by orbiters. 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 deployed on ESA's ExoMars lander "Schiaparelli" [3] and it has been requested by NASA to ASI for the Mars 2020 Rover and InSight 2018 Lander missions. 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

[1] Probing gravity with next-generation lunar la-ser ranging, M. Martini and S. Dell'Agnello, in R. Peron et al. (eds.), Gravity: Where Do We Stand?, DOI 10.1007/978-3-319-20224-2_5, Springer Inter-national Publishing, Switzerland (2016).

[2] Formation flying, cosmology and general relativity: a tribute to far-reaching dreams of Mino Freund, Currie, D.; Williams, J.; Dell'Agnello, S.; Monache, G.D.; Behr, B. and K. Zacny, in Springer Proceedings in Physics, vol. 150, ISBN-13: 978-3319022062, ISBN-10: 3319022067 (2014).

[3] INRRI-EDM/2016: the first laser retroreflector on the surface of Mars, S. Dell'Agnello et al., Advances in Space Research 59 (2017) 645–655.