**Introduction:** The Lunar Laser Ranging (LLR) experiment is the living legacy of Apollo program. The first deployment of such a package on the lunar surface took place during the Apollo 11 mission in the summer of 1969, making LLR a reality. Additional retroreflector packages were set up by the Apollo 14 and 15 astronauts. The goal was to place arrays at three lunar locations to study the Moon’s motion. Two French-built retroreflector arrays were on the Lunokhod 1 and 2 rovers placed on the Moon by the Soviet Luna 17 & Luna 21 missions, respectively [1].

Since its initiation by the Apollo 11 astronauts in 1969, LLR has strongly contributed to our understanding of the Moon’s internal structure and the dynamics of the Earth-Moon system. The data provide for unique, multi-disciplinary results in the areas of lunar science, gravitational physics, Earth sciences, geodesy and geodynamics, solar system ephemerides, and terrestrial and celestial reference frames [1-5].

However, the current distribution of the retroreflectors is not optimal, other weaknesses exist [4]. A geographic distribution of new instruments on the lunar surface wider than the current distribution would be a great benefit; the accuracy of the lunar science parameters would increase several times. A bright transponder source on the Moon would open LLR to dozens of satellite laser ranging stations which cannot detect the current weak signals from the Moon.

**New Instruments:** We are developing the next-generation of the LLR experiment. This work includes development of new retroreflector arrays and laser transponders to be deployed on the lunar surface by a series of upcoming missions to the moon. The effort is synergetic with other science investigations and instruments that potentially are going to be deployed on the moon with the upcoming landers (i.e., seismometers, heat-flow instruments, etc.).

The new laser instruments will enable strong advancements in the area of LLR-derived science. Anticipated science impact includes lunar science, gravitational physics, geophysics, and geodesy. Thus, properties of the lunar interior, including tidal properties, liquid core and solid inner core can be determined from lunar rotation, orientation, and tidal response. Anticipated improvements in Earth geophysics and geodesy would include the positions and rates for the Earth stations, Earth rotation, precession rate, nutation, and tidal influences on the orbit. Strong improvements are also expected in several tests of general relativity.

Science investigations with optical transponders on the Moon can also be used as a prototype demonstration for later laser ranging to Mars; a lunar installation would provide valuable early feedback on their operational characteristics. Laser transponders could also be coupled with optical communication capabilities to enable significant data rates for information transmitted to the Earth [4].

We address the science return enabled by the new generation of laser retroreflector arrays and optical transponders. In addition to vastly improved accuracy of gravitational physics parameters (i.e., tests of the Equivalence Principle, variability in the gravitational constant $G$, and determination of PPN ($\beta$ and geodetic precession)), the instruments will enable new science investigations on and of the moon [2,3]. A wider spread of arrays on the Moon would directly benefit lunar science by improving the accuracy of the lunar rotation and tide determinations and the relevant effects. Improving the accuracy of existing parameters opens up new possibilities. Currently undetected effects involve the solid inner core. An inner core would introduce a number of subtle modifications to the lunar rotation, orientation and tides which can be used to learn about its properties [4,5].

We discuss new laser retroreflector arrays and report on their potential design and technology. We also discuss identification and optimization of their science return as a function of their deployment scenario and resulting distribution on the lunar surface. For laser transponders we discuss their pointing, power, and thermal requirements; and will also address their design, relevant technology, operational concepts, and deployment scenarios, and determination of their science return as a function of their lifetime.

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