A LUNAR LASER REFLECTOR FOR THE 21ST CENTURY D. G. Currie[1,2,3], S. Dell'Agnello[3] and G. Delle Monache[3], [1]Department of Physics, University of Maryland College Park, MD 20904, currie@umd.edu, [2]NASA Lunar Science Institute, [3]Istituto Nazionale di Fisica Nucleare Laboratori, Nazionali di Frascati.

Introduction: The Lunar Laser Ranging Program using the Apollo Cube Corner Retroreflector (CCR) Arrays [1] has operated as the only experiment on the lunar surface for the past four decades . During this time it has contributed to the determination of the properties of the lunar surface (Love numbers) and provided information on the existence, size and shape of the fluid core. It has also addressed the lunar orbit, the oscillations and Q of the moon[2]. It has also supplied almost all of the significant tests of General Relativity. The Lunar Laser Ranging Program has evaluated the PPN parameters, addressed the possible changes in the gravitational constant and the properties of the self-energy of the gravitational field. This is the only Apollo experiment that is still in operation. Initially the Apollo Cube Corner Retroreflector (CCR) Arrays contributed a negligible fraction of the ranging error budget. Over the decades, the ranging capabilities of the ground stations have improved by more than two orders of magnitude. Now, after forty years the existing Apollo retroreflector arrays contribute a significant fraction of the limiting errors in the range measurements. This is due to the lunar librations tilting of the array of CCRs and thus contribution to the spreading of the laser pulse. Thus shorter laser pulses have no advantage and we have afunamental width of the return laser pulse to use for timeing due to the lunar librations.

The University of Maryland, as the Principal Investigator for the original Apollo arrays, is now proposing a new approach to the Lunar Laser Array technology [3]. The investigation of this new technology, by two teams with Professor Currie as Principal Investigator, is currently being supported by two NASA programs, the Lunar Science Sortie Opportunities (LSSO) and Lunar University Network for Astrophysical Research (LUNAR). The latter is a joint program centered at the University of Colorado and addresses cosmological and heio-physics by radar procedures on the far side of the moon in addition to the Lunar Laser Ranging. The LUNAR program is funded through NASA Lunar Science Institute NLSI. Both LSSO and the LUNAR-LLR programs are in collaboration with the INFN-LNF in Frascati, Italy. After the proposed installation during the next lunar landing, the new arrays will support ranging observations that are a factor 100 more accurate than the current Apollo Cube Corner Retroreflector (CCR) Arrays.

The new fundamental cosmological physics and the lunar physics [3] that this new Lunar Laser Ranging Retroreflector Array for the 21st Century (LLRRA-21) can provide will be described. In the initial design of the new array, there are three major challenges: 1) Validate the ability to fabricate a CCR of the required specifications, which are significantly beyond the properties of current CCRs; 2) Address the thermal and optical effects of the absorption of solar radiation within the CCR, reduce the transfer of heat from the CCR housing and; 3) Validate an emplacement technique for the CCR package on the lunar surface such that the relation between the optical center of the array and the center of mass of the moon remains stable over the lunar day/night cycle and the long term.

To assure the stability of the emplacement over a lunation, it is desirable to mount the CCR on a support rod that is anchored in the regolith at a depth of about one meter. One candidate for accomplishing this requirement is provided by the pneumatic drilling technique of the Honeybee Corporation. We will report on the results of a field test of the pneumatic drilling proceudre to be conducted within a join field test conducted by the Canadian Space Agency and NASA on Mauna Kea in Hawaii. This will use a one meter drill with a 100 mm CCR mounted on the support rod. We will also report on the most recent thermal simulations of the CCR, the CCR housing, the support rod and the regolith. The objective is to assure that the optical quality of the CCR is maintained sufficiently to assure an adequatd retrun to the laser ranging stations on edarth. We shall particularly focus on the new stress modeling and of the launch conditions as opposed to the methods under consideration for the emplacement on the lunar surface such that the CCR remains linked to the center of mass of the moon to the micron level.

References: [1] C. O. Alley.; R. F. Chang.; D. G. Currie; et.al. (1970) Science, Volume 167, Issue 3918, pp. 458-460

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