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A LUNAR LASER RANGING ARRAY FOR THE 21ST CENTURY

Abstract

Over the past forty years, Lunar Laser Ranging (LLR) to the Apollo Cube Corner Reflector (CCR) arrays has supplied almost all of the significant tests of General Relativity. LLR has evaluated the PPN parameters and addressed, for example, the possible change in the gravitational constant and the self-energy of the gravitational energy. In addition, LLR has provided significant information on the composition and origin of the moon. Initially the Apollo Lunar Arrays contributed a negligible portion of the error budget used to achieve these results. Over the decades, the performance of ground stations has greatly upgraded so that the ranging accuracy has improved by more than two orders of magnitude, i.e., a factor of 140. Now, after forty years, because of the lunar librations the existing Apollo retroreflector arrays contribute significantly to the limiting error in the range measurements. The University of Maryland, as the Principal Investigator for the original Apollo arrays, is now proposing a new approach to the Lunar Laser CCR array technology. The investigation of this new technology is currently being supported by two NASA programs. Thus after installation on the next Lunar landing, the new arrays will reduce the contribution of the lunar emplacement by more than two orders of magnitude, from the centimeter level to the micron level. The new fundamental physics and the lunar physics that this can provide will be discussed. In the design of the new array, there are three major challenges: 1) Address the thermal and optical effects of the absorption of solar radiation within the CCR 2) Reduce the transfer of heat from the hot housing to the CCR and 3) Define a method of emplacing the CCR package on the lunar surface such that it is stable over the lunar day/night cycle. The design approach, the computer simulations using Thermal Desktop, Code V and locally developed IDL software, and the thermal vacuum testing conducted at the INFN/LNF's SCF facility at Frascati of the new array will also be presented. For example, the new lunar CCR housing has been built at INFN/LNF. The latter will include a discussion of the innovations over the Apollo arrays and current satellite retroreflector packages. This new concept for a CCR for Lunar Laser Ranging is being considered for the NASA Manned Lunar Landings, for the NASA Anchor Nodes for the International Lunar Network and for the proposed Italian Space Agency's MAGIA lunar orbiter mission.