

A geodesy surface package for future Lunar missions

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We propose to deploy state-of-the-art lunar geodesy packages on the Moon's surface, consisting of a novel one-way laser ranging experiment, as well as microwave- and radio beacons. The ranging experiment will consist of a Laser pointed towards the Earth and firing short pulses at a clock controlled repetition rate. We estimate that the received signal strength from a 50 mJ pulse Laser illuminating the entire Earth is approximately 3 orders of magnitude larger than a typical Laser ranging signal returning from the passive Lunar retroreflectors. Hence, such Laser shots could be received by most of the existing more than 30 ILRS (International Laser Ranging Service) stations. As a result, significantly more Lunar range measurements at higher accuracy and unbiased temporal coverage will become available. From observations by multiple stations, systematic measurement errors, such as atmospheric travel time delay and Laser clock drift can be identified and removed. The experience from the past 38 years of Apollo Lunar Laser Ranging (LLR) suggests that there is enormous science potential in ranging data to further our understanding of the Moon's internal structure, the dynamics of the Earth-Moon system and fundamental physics. For example, from the Moon's tidal response, inferences can be made on a solid or liquid Lunar core and its size and oblateness. In addition, parameters from gravitational physics, e.g., the time-stability of the gravitational "constant", or the strong equivalence principle (Nordtvedt-effect) could be modeled with vastly improved accuracy. Small microwave and radio sources shall be deployed along with the Laser within the package. While the position of the Laser will define an important anchor point in the lunar-fixed coordinate system, the microwave and radio transmitters will firmly tie the dynamical reference frame of the Lunar orbit into the quasi-inertial kinematic reference frame of

Quasar coordinates as well as the International Terrestrial Reference Frame, realized, a.o., by the GPS system. The microwave transmitter observed by VLBI will permit us to track the tangential motion of the Moon in inertial space for insights into the Moon's orbital behavior to as yet unknown frontiers.