

Lunar Laser Ranging for Testing Relativity and Studying the Earth-Moon System

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Abstract

Lunar Laser Ranging (LLR) has provided the distance between the Earth and Moon for more than 54 years. With the development of the instrumentation at the observatories, data accumulation and the improvements in LLR modelling and data analysis, LLR plays an ever increasing role in many research fields, e.g., related to relativity tests, the determination of Earth orientation parameters (EOPs) and lunar interior modelling. LLR's relevance will further increase with the new lunar missions that will deploy further reflectors. In this presentation, we give an overview of various LLR applications and our recent LLR results at IfE.

Different tests of General Relativity have been carried out. For testing the equivalence principle (EP) in the gravitational field of the galactic dark matter and the Sun, the relevant EP parameters were determined. Also the equivalence of active and passive gravitational mass of the Moon has been investigated. Further relativity tests covered a possible temporal variation of the gravitational constant, the PPN parameters γ for the size of space curvature and β related to the nonlinearity of gravity.

Concerning Earth rotation, we used an LLR time series with a minimum of 15 NPs per night to estimate the Earth rotation phase UT1 with an accuracy of comparable to VLBI for the best nights and the terrestrial pole coordinates x_p and y_p .

A further study addressed an advanced LLR technique, i.e. Differential Lunar Laser Ranging (DLLR), with an expected very high measurement accuracy of about 30 μm , which is planned to be realized at the Table Mountain Observatory of JPL in the future. By using simulated DLLR data with the same timespan as LLR, the parameter estimation related to the lunar interior could be enhanced by about two orders of magnitude. Also, a combined analysis of LLR and DLLR data has been performed, especially benefiting the parameters of the lunar interior.

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