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Advanced instrumentation for Solar System gravitational physics

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The Solar System is a complex laboratory for testing gravitational physics. Indeed, its scale and hierarchical structure make possible a wide range of tests for gravitational theories, studying the motion of both natural and artificial objects. The usual methodology makes use of tracking information related to the bodies, fitted by a suitable dynamical model. Different equations of motion are provided by different theories, which can be therefore tested and compared. Future exploration scenarios show the possibility of placing deep–space probes near the Sun or in outer Solar System, thereby extending the available experimental data sets.

In particular, the Earth–Moon is the most accurately known gravitational three–body laboratory, which is undergoing a new, strong wave of research and exploration (both robotic and manned). In addition, the benefits of a synergetic study of planetary science and gravitational physics are of the greatest importance (as shown by the success of the Apollo program), especially in the Earth–Moon, Mars–Phobos, Jovian and Saturnian sub–suystems.

This scenarios open critical issues regarding the quality of the available dynamical models, i.e. their capability of fitting data without an excessive number of empirical hypotheses. A typical case is represented by the non–gravitational phenomena, which in general are difficult to model. More generally, gravitation tests with Lunar Laser Ranging, inner or outer Solar System probes and the appearance of the so–called "anomalies"(like the one indicated by the Pioneers), whatever their real origin (either instrumental effects or due to new physics), show the necessity of a coordinated improvement of tracking and modelization techniques.

A common research path will be discussed, employing the development and use of advanced instrumentation to cope with current limitations of Solar System gravitational tests. In particular, the use of high–sensitivity accelerometers, combined with microwave and laser tracking, will be discussed.