A Novel Two-Step Laser Ranging Technique for a Precision Test of the Theory of Gravity

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Abstract

All powered spacecraft experience residual systematic accelerations due to anisotropy of the thermal radiation pressure and fuel leakage. The residual accelerations limit the accuracy of any test of gravity that relies on the precise determination of the spacecraft trajectory. We describe a laser ranging scheme, which largely eliminates the effects of non-gravity acceleration sources and enables celestial mechanics checks with unprecedented precision. A passive proof mass is released from the mother spacecraft on a solar system exploration mission. Retroreflectors attached to the proof mass allow its relative position to the spacecraft to be determined using optical ranging techniques. Meanwhile, the position of the spacecraft relative to the Earth is determined by ranging with a laser transponder. The vector sum of the two is the position, relative to the Earth, of the proof mass, the measurement of which is not affected by the residual accelerations of the mother spacecraft. We also describe the mission concept of the Dark Matter Explorers (DMX), which will demonstrate this technology and will use it to test the hypothesis that dark matter congregates around the sun. This hypothesis implies a small apparent deviation from the inverse square law of gravity, which can be detected by a sensitive experiment.