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GRACE-enabled Space Geodetic Experiments for Fundamental Physics

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Space geodesy provided the most accurate station positions and velocities and the most accurate orbits of artificial satellites. To achieve such high quality, the motion of these satellites must be described with equally accurate models, such as those made available recently, thanks to missions like CHAMP and GRACE. This led to the synergistic application of such precise products to devise tests of fundamental physics theories. Nearly twenty years after conceiving and proposing a test concept for a General Relativity (GR) test of the gravitomagnetic effect of the rotating Earth, our recent analyses resulted in a convincing measurement of the Lense-Thirring effect. Using state-of-the-art Earth gravitational field models we obtained an accurate measurement of the Lense-Thirring effect predicted by GR, analyzing LAGEOS and LAGEOS 2 Satellite Laser Ranging (SLR) data. The new result, in agreement with that based on earlier Earth models JGM-3 and EGM96, is far more accurate and robust. Our analysis uses only the nodal rates of the two satellites, making no further need to use the perigee rate, thus eliminating the dependence on this unreliable element. Using the EIGEN-GRACE02S model, we obtained our optimal result: mu (μ) = 0.99 (vs. 1.0 in GR), with a total error between 5% and 10 % of the GR prediction. Further improvement of the gravitational models since then led to even more accurate tests, the results of which we will present and discuss. We also discuss some of the crucial areas to be considered in designing the future LARES mission dedicated to measuring even more accurately the Lense-Thirring effect.