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Testing Local Lorentz Invariance with the LAGEOS II satellite

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The Preferred Frame Effects (PFE), in the framework of the Parametrized-Post Newtonian (PPN) formalism, valid in the weak-field and slow-motion (WFSM) limit of General Relativity (GR), are described by the three parameters α_1 , α_2 and α_3 , all equal to zero in GR and in tensor-scalar theories of gravity. A test of PFE is equivalent to a test of Local Lorentz Invariance (LLI), which represents a pillar of GR. In essence, LLI states that the result of any local (in space and time) non-gravitational test experiment is independent of the speed of the free-falling apparatus in which the experiment is conducted.

We present, in the WFSM limit of GR, a measurement of the parameter α_1 based on the analysis of the orbital residuals of the passive geodetic satellite LAGEOS II over a time interval of approximately 28 years. LAGEOS II is very well tracked through the powerful Satellite Laser Ranging (SLR) technique. We considered the possible existence of PFE due to the motion of the Earth-Sun-satellite system with respect to the Cosmic Microwave Background radiation and analyzed the effects on the satellite's longitude.

It is important to stress that LLI is well tested in high-energy physics experiments but is much more difficult to test in the gravitational context, both in the weak-field regime and in the strong- or quasi-strong-field regime. In the weak-field regime, the best results in constraining the parameters α_1 and α_2 were obtained through the Lunar Laser Ranging (LLR) technique.

The result we obtained is in line with a null value for the α_1 parameter and improves the constraint obtained with LLR. Therefore, this improved limit for the PPN parameter constrains further the possible existence vector-tensor theories of gravity.

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