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Astronomical Tests of Spatial Anisotropy of Gravity: Lunar Laser Ranging and Trans-Neptunian Object Anomalies in the Context of the Spin-Density Model

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Spatial anisotropy of the gravitational constant G is a key prediction of the Spin-Density Model (SDM), in which space-time is considered as a dynamic carrier medium. According to the SDM, large-scale polarization of this medium by active galactic nuclei leads to a dependence of the effective gravitational constant on direction, manifesting as a difference in gravitational attraction in the Galactic plane and perpendicular to it. The astrophysical estimate of this effect gives $\Delta G/G \sim 10^{-8}$, whereas in laboratory conditions on Earth the effect should be suppressed by the local gravitational field to $\Delta G/G \sim 10^{-10}$. Existing gravimetric constraints ($\Delta G/G < 6 \times 10^{-10}$) do not contradict this prediction but cannot confirm it due to scale limitations.

This paper argues for the necessity of transitioning to astronomical tests that allow probing the anisotropy of G on scales where the influence of local masses is minimal. Two complementary directions are considered: Lunar Laser Ranging (LLR) and analysis of Trans-Neptunian Object (TNO) anomalies. LLR provides precision measurement of the Moon's orbit and constrains anisotropy parameters ($\alpha_2 \approx 2 \times 10^{-5}$), yet its sensitivity to the anisotropy itself is still inferior to gravimetric constraints. TNOs, in turn, provide a statistically significant sample of orbits at distances of 30–150 AU, where the contribution of carrier medium polarization becomes relatively more prominent. Anomalies in the distribution of TNO orbital parameters, usually attributed to a hypothetical "Planet Nine," receive a natural explanation within the SDM as a consequence of the large-scale polarization "texture" of space-time.

Prospects for using long-period comets and the Oort cloud, as well as future surveys (LSST), to refine SDM predictions are discussed. It is shown that a joint analysis of LLR and TNO data allows not only testing the hypothesis of spatial anisotropy of gravity but also verifying the ontological principles of the SDM as a whole. Specific experimental and observational strategies aimed at detecting the effect at the 10^{-10} level and below are proposed.

Keywords: spatial anisotropy of gravity; gravitational constant; Spin-Density Model; Lunar Laser Ranging; Trans-Neptunian Objects; dark matter; Planet Nine.

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