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PARTICLE AND NUCLEAR ASTROPHYSICS AND COSMOLOGY

Cover Story (Issue 8, 2025) A Novel Perspective on Spacetime Perturbations: Bridging Riemannian and Teleparallel Frameworks

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In a recent article [1], the authors present a compelling theoretical innovation by reinterpreting spacetime perturbations through the lens of teleparallel gravity, while maintaining a Riemannian geometric background. This work elegantly bridges two distinct geometric formulations of gravity—curvature-based general relativity and torsion/non-metricity-based teleparallel theories—offering new insights into perturbation theory and expanding the toolkit for studying gravitational phenomena.

The authors' central idea—decoupling the gravitational representation of the background (described by Riemannian curvature) from that of perturbations (encoded via torsion or non-metricity)—is both novel and impactful. By doing so, they derive teleparallel-like actions for perturbations, effectively unifying the mathematical advantages of teleparallel gravity (e.g., simpler field equations in certain contexts) with the physical clarity of Riemannian backgrounds. This approach not only enriches perturbation theory but also opens new avenues for exploring modified gravity scenarios, where perturbations might exhibit non-standard dynamics. Furthermore, torsion and non-metricity have also been used to formulate the topological defects in the continous media. Torsion meaures dislocations, a kind of linear defects, while non-metricity naturally charactrises point-like defects in the crystals. The article [1] depicts an image where spacetime perturbations can be seen as topological defects on a uniform background.

The technical implementation of this work is rigorous and reliable. The metric formulation demonstrates how non-metricity captures perturbations, yielding a quadratic action where derivatives of perturbations are isolated in the non-metricity scalar. Similarly, the tetrad formulation links perturbations to torsion, with dynamics governed by the torsion scalar. Both frameworks elegantly reduce to their respective teleparallel equivalents for flat backgrounds, showcasing consistency.

In summary, the authors of Ref. [1] have made a significant contribution to gravitational physics by establishing an important theoretical framework. Their quasi-teleparallel framework not only advances perturbation theory but also reinforces the profound interplay between geometry and gravity. This paper is a must-read for researchers in modified gravity and cosmology.

References

[1] J. Gao, Y. Kang, M. Li, and Y. Tong, Chin. Phys. C 49, 085105 (2025), arXiv: 2503.03119 [gr-qc].