PLANCK SCALE DEFORMATIONS OF THE POINCARÉ ALGEBRA AND OF THE HYPERSURFACE-DEFORMATION ALGEBRA

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Outline

1. Quantum-gravity problem
2. Project
3. First steps

Quantum-gravity problem

- The field of theoretical physics which attempts to reconcile General Relativity of Einstein and Quantum Mechanics;
- The relevant regime is very far from our direct experimental access;
- The characteristic length scale of these effects should be the Planck length $L_P = \sqrt{\frac{\hbar G}{c^3}} \approx 10^{-35} m$, which corresponds to the energy scale given by the Planck scale $E_P = \sqrt{\frac{\hbar c^5}{G}} \approx 10^{28} eV$ (we denote the speed-of-light scale with c, the Newton constant with G and the Planck constant with $\hbar$);
- The most studied approaches are String Theory, Loop Quantum Gravity and Spacetime Noncommutativity.

Expectation

- In this distant scale spacetime would manifest new (non-Riemannian) geometric properties;
- Possible associated Planck-scale deformations of some relevant symmetry algebras are present in the spacetime quantization picture. This could lead to very rare cases when Planck-scale effects give rise to actually testable predictions.

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Targets

- Investigate scenarios for spacetime-quantization-induced deformations of the Poincaré algebra;
- Contribute to a deeper understanding of the possibility of Planck-scale deformations of the so-called "Hypersurface deformation algebra", a type of Planck-scale deformation whose potential significance for quantum-gravity research started to be advocated only very recently;
- Attempt the development of phenomenological research programs inspired by our findings.

Outline

First steps

Perform some investigations inspired mainly by the study reported by Bojowald and Paily[1], which advocates a role in Loop Quantum Gravity for a certain class of Planck-scale deformations of the hypersurface-deformation algebra.

[1] M. Bojowald and G. M. Paily, *Deformed General Relativity*, Phys. Rev. D 87 (2013) 044044 [arXiv:1212.4773 [gr-qc]]

Hypersurface-deformation algebra

- The algebra of the smeared constraints of the Hamiltonian formulation of general relativity;
- It is an efficient way for codifying general covariance;
- It reproduces the classical Poincaré algebra in an appropriate limit.

Investigation of interest

How does the Bojowald-Paily proposal of Planck-scale-deformed hypersurface-deformation algebra reproduce in an appropriate limit a Planck-scale-deformed Poincaré algebra?

Objective

Look for a noncommutative-spacetime model consistent with Bojowald-Paily's picture, where it is assumed a spherical symmetry.
A natural candidate would be the much-studied κ-Minkowski spacetime.

Spacetime noncommutativity

- The emergence of a non-classical ("quantum") picture of spacetime is expected in quantum gravity;
- It explores the possibility that spacetime coordinates do not commute;
- It might be needed for a fundamental description of spacetime structure.

A noncommutative spacetime which is characterized by the following coordinate-noncommutativity relations

$$[\hat{X}_0, \hat{X}_j] = i\lambda \hat{X}_j, \qquad [\hat{X}_j, \hat{X}_k] = 0,$$

where $\hat{X}_0$ is the time coordinate, $\hat{X}_j$, $j = 1, 2, 3$, are the spatial coordinates and λ is a characteristic length scale often assumed to be of at least roughly the order of the Planck length L_P.

Search

Match the form of the Planck-scale-deformed Poincaré algebra derived by the Bojowald-Paily deformed hypersurface-deformation algebra and the form of the Planck-scale-deformed Poincaré algebra derived by analyzing the relativistic symmetry of a quantum spacetime.

References

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Thank you for your attention!