DECOHERENCE MEETS TSALLIS: A NEW TAKE ON QUANTUM THERMOSTATISTICS

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ABSTRACT

Generalized Uncertainty Principle (GUP) is a phenomenological framework designed to incorporate a *minimal length scale* — such as the Planck scale or a characteristic inverse-mass scale in effective quantum theories — into quantum mechanics. In this talk, I will explore potential *observable consequences* of GUP in the *decoherence regime*. First, I construct *coherent states* associated with GUP and demonstrate that, in the momentum representation, these states coincide with *Tsallis-type probability amplitudes*, where the *non-extensivity parameter q* increases monotonically with the GUP deformation parameter β. Second, in the regime $\beta < 0$ (i.e., $q < 1$), I show — using the *Beckner–Babenko inequality* — that GUP becomes *fully equivalent* to *information-theoretic uncertainty relations* based on *Tsallis entropy power*. Finally, I apply the *Maximum Entropy Principle* from estimation theory to uncover a connection between the *quasi-classical (decoherence) limit* of GUP-based quantum theory and the *nonextensive thermostatistics* of Tsallis. This connection suggests a potentially rich and unifying paradigm, bridging quantum theory and analog gravity. Notably, in certain quantum gravity models — such as *conformal gravity*—the quasi-classical regime shaped by this framework may have *observable implications*. I will conclude with a discussion of some of these implications.

REFERENCES

[1] P. Jizba, G. Lambiase, G. Luciano and L. Petruzziello, Decoherence limit of quantum systems obeying generalized uncertainty principle: New paradigm for Tsallis thermostatistics, *Physical Review D* vol.105, L121501, 2022.
[2] P. Jizba, G. Lambiase, G. Luciano and L. Petruzziello, Coherent states for generalized uncertainty relations as Tsallis probability amplitudes: New route to nonextensive thermostatistics, *Physical Review D* vol. 108, 064024, 2023.