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Generalization of Quantum Decay Laws and Spectral Decomposition via a Canonical Time Operator in Deformed Algebras Induced by Gravitational Effect

This work studies how the generalization of the energy–time uncertainty principle, induced by quantum gravity effects, modifies the decay laws of quantum systems. Since the energy–time uncertainty relation constrains the behavior of these laws, its modification naturally implies an alteration in the way unstable systems decay. For this reason, a generalized version of the Fock–Krylov formalism is constructed from the deformed algebra, which allows quantum-gravitational corrections to be incorporated into the energy representation and into the time evolution. As an application, the decay of a Lorentzian or Breit–Wigner spectrum is analyzed, yielding a modified decay law and a relation between the corrected mean lifetime and the classical lifetime. The corrections are found to be of the order of the Planck time and are therefore negligible at macroscopic scales, becoming relevant only in regimes very close to the Planck scale. Finally, under a thermodynamic approach and assuming the Stefan–Boltzmann law to be valid, the modification to the evaporation time of a Schwarzschild black hole is estimated using effective temperatures of a micro black hole. The work aims to contribute to understanding what kind of effects could be expected in quantum systems that decay at scales close to the Planck scale.

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