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Gravity versus Quantum Particle Dynamics

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The question of compatibility between our theory of gravity, more or less along the line of General Relativity, and basic notions of quantum physics has been a major concern. We focus, in particular, on an exact Weak Equivalence Principle and the notion of the momentum observable for a particle as a vector quantity with an invariant magnitude as given through the metric. Contrary to the problems in the Schr\"odinger wavefunction representation, we give a formalism of quantum mechanics in curved spacetime through the Heisenberg picture, supplemented by a noncommutative geometric perspective, that maintains the features. Quantum particle dynamics should be seen as one on a quantum, noncommutative, geometric model of spacetime with a metric that defines the inner product between vectors as observables as well as the inner product for the vector space of states in the Schr\"odinger picture. Then, quantum gravity is about quantum spacetime. We also address the Relativity Principle with quantum reference frame transformations.
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