General Relativity and Quantum Cosmology

Quantum theory, noncommutative gravity, and the cosmological constant problem

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The cosmological constant problem is principally concerned with trying to understand how the zero-point energy of quantum fields contributes to gravity. Here we take the approach that by addressing a fundamental unresolved issue in quantum theory we can gain a better understanding of the problem. Our starting point is the observation that the notion of classical time is external to quantum mechanics. Hence there must exist an equivalent reformulation of quantum mechanics which does not refer to an external classical time. Such a reformulation is a limiting case of a more general quantum theory which becomes nonlinear on the Planck mass/energy scale. The nonlinearity gives rise to a quantum-classical duality which maps a `strongly quantum, weakly gravitational' dynamics to a `weakly quantum, strongly gravitational' dynamics. This duality predicts the existence of a tiny nonzero cosmological constant of the order of the square of the Hubble constant, which could be a possible source for the observed cosmic acceleration. Such a nonlinearity could also be responsible for the collapse of the wave-function during a quantum measurement. We conclude by suggesting that the idea for the origin of dark energy proposed in this paper can be tested indirectly in the laboratory by a detailed examination of the process of quantum measurement.

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