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The Noise of Gravitons

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For the purpose of describing observed phenomena, it has thus far been sufficient to regard gravity as a classical field obeying Einstein's equations. Here we treat the gravitational field as a quantum field and consider the implications for gravitational wave detectors. We present a formalism to obtain the quantum effects of gravity based on the Feynman-Vernon influence functional. We find that the separation of free-falling particles is subject to random fluctuations ("noise"), with the classical geodesic deviation equation being replaced by a stochastic equation. The statistical characteristics of the noise depend on the quantum state of the gravitational field; for certain classes of quantum states, the noise can be greatly enhanced. Detection of this fundamental noise would constitute direct evidence for the quantization of gravity and the existence of gravitons.

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