MAR16-2015-020262

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Gravity and Quantum Mechanics[1]

MILES BLENCOWE, Dept. of Physics and Astronomy, Dartmouth College, Hanover NH 03755

The emergence of the macroscopic classical world from the microscopic quantum world is commonly understood to be a consequence of the fact that any given quantum system is open, unavoidably interacting with unobserved environmental degrees of freedom that will cause initial quantum superposition states of the system to decohere, resulting in classical mixtures of either-or alternatives. A fundamental question concerns how large a macroscopic object can be placed in a manifest quantum state, such as a center of mass quantum superposition state, under conditions where the effects of the interacting environmental degrees of freedom are reduced (i.e. in ultrahigh vacuum and at ultralow temperatures). Recent experiments have in fact demonstrated manifest quantum behavior in nano-to-micron-scale mechanical systems. Gravity has been invoked in various ways as playing a possible fundamental role in enforcing classicality of matter systems beyond a certain scale. Adopting the viewpoint that the standard perturbative quantization of general relativity provides an effective description of quantum gravity that is valid at ordinary energies, we show that it is possible to describe quantitatively how gravity as an environment can induce the decoherence of matter superposition states. The justification for such an approach follows from the fact that we are considering laboratory scale systems, where the matter is localized to regions of small curvature. As with other low energy effects, such as the quantum gravity correction to the Newtonian potential between two ordinary masses, it should be possible to quantitatively evaluate gravitationally induced decoherence rates by employing standard perturbative quantum gravity as an effective field theory; whatever the final form the eventual correct quantum theory of gravity takes, it must converge in its predictions with the effective field theory description at low energies.

[1]Research supported by the National Science Foundation (NSF) and the Foundational Questions Institute (FQXi).