Abstract Submitted
for the MAR16 Meeting of
The American Physical Society

Einstein's Equivalence Principle and Universal Decoherence in Massive Composite Quantum Systems BELINDA PANG, YANBEI CHEN, Caltech — We demonstrate that in matter wave interferometry, the presence of a uniform gravitational field acting on massive particles with internal degrees of freedom will lead to dephasing and a loss of visibility in the interference pattern, as also shown by previous authors. However,unlike the previous authors,we argue that this is not a universal decoherence mechanism in the sense that any quantum information is lost, and furthermore,that the quantum interference is recoverable.This is a key distinction, becauseirreversible effects such as decoherence on a quantum system due to uniform gravity impliesa violation of Einstein's Equivalence Principle (EEP)in the quantum regime.We show that the dephasing result can be recovered by considering an accelerating observer measuring a freely propagating system, and can be simply understood in terms of the difference in the internal state dependent time of arrival of particles to the screen. One can contrive detection schemes that adjusts the path lengths of particles to compensate for this difference and recover the full visibility, while coupling to no additional degrees of freedom.Therefore, the dephasing is an observer dependent effect. EEP is not violated, and uniform gravity is not a mechanism for universal decoherence.

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Date submitted: 06 Nov 2015 Electronic form version 1.4