Abstract Submitted
for the MAR07 Meeting of
The American Physical Society

Matter-Wave Decoherence in an Atom Interferometer: Which-Way vs. Classical Fluctuations SCOTT SANDERS, FLORIAN MINTERT, ERIC HELLER, Harvard University — We present a theoretical treatment of decoherence in an atom interferometer by two seemingly disparate approaches. One arm of the interferometer contains a background gas; any collision with the background gas would constitute a "which way" detection and decoherence. Yet coherence can largely be retained in spite of large phase shifts acquired by atoms passing through the background gas. How can the atoms "interact" with the gas, producing a phase shift, without "touching" (i.e., giving even a gentle shove to) the atoms of the background gas? This story has a prosaic but instructive resolution in terms of the quantum cross section for scattering; however, a semi-classical treatment of the fluctuating forces experienced by the initially coherent atom traversing the background gas may give essentially the same result for both the phase shift and the decoherence. We discuss the generality and limitations of this method. Our results resolve the fundamental question of when the scattering interactions that cause the index of refraction constitute a which-way measurement for the path of atoms through the interferometer.

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Date submitted: 27 Dec 2006 Electronic form version 1.4