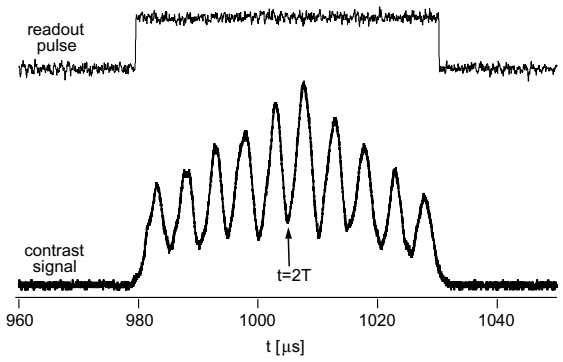
Contrast Interferometry using Bose-Einstein Condensates to Measure h/m and α

We have demonstrated a new atom interferometer scheme, which shows promise for a high precision measurement of the recoil energy of an atom [1]. A precise measurement of the recoil frequency will lead to a more precise determination of h/m and of the fine structure constant α.

Our interferometer extends previous schemes used at Stanford [2] and New York [3], and combines their advantages. Optical standing wave pulses were used to create a symmetric three-path interferometer. This configuration encodes the photon recoil phase in the contrast of the interference fringes, rather than in their phase. Because it is insensitive to the fringe phase, the method is not sensitive to vibrations, accelerations, or rotations. The symmetry also suppresses errors from magnetic field gradients, and our use of only one internal state suppresses errors arising from differences in the ac Stark shifts between different internal states. A crucial aspect of this new interferometer is the use of atomic samples with sub-recoil momentum distribution. We use a Bose-Einstein condensate (BEC) as a bright sub-recoil atom source. This allows the contrast oscillations to persist for many cycles, permitting precise determination of the recoil phase in a single "shot."



Typical single-shot signal from the contrast interferometer. The contrast signal is the intensity of a laser beam reflected by the interfering atomic matter waves. It represents the beat note between two simple interference patterns. Ten oscillations with 60 % are observed during the 50 μs readout.

1. S. Gupta, K. Dieckmann, Z. Hadzibabic, and D.E. Pritchard, *Contrast Interferometry using Bose-Einstein Condensates to Measure h/m and α*, Phys. Rev. Lett. **89**, 140401 (2002).
2. D.S. Weiss, B.C. Young, and S. Chu, *Precision Measurement of the Photon Recoil of an Atom Using Atomic Interferometry*, Phys. Rev. Lett. **70**, 2706 (1993).
3. S.B. Cahn, A. Kumarkrishnan, U. Shim, T. Sleator, P.R. Berman, and B. Dubetsky, *Time-Domain de Broglie Wave Interferometry*, Phys. Rev. Lett. **79**, 784 (1997).