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Quantum Coherence in a Disordered Bose-Einstein Condensate[1]

YONG P. CHEN, J. HITCHCOCK, D. DRIES, M. JUNKER, C. WELFORD, R.G. HULET, Department of Physics and Astronomy and Rice Quantum Institute, Rice University, Houston TX 77005 — Quantum coherence underlies such phenomena as superfluids and superconductors. We have performed an experiment on a Bose-Einstein condensate (BEC) subjected to a disordered potential, and found evidence that finite quantum coherence may still exist in an insulating state. We create a large BEC of ^{7}Li atoms in their (1,1) state in an elongated optical dipole trap. We then project laser speckle onto the atoms to make a disordered potential, where the disorder strength (V_d) is tunable by varying the laser intensity. As V_d is increased, we observe a suppression of the center of mass transport (dipole motion) of the trapped BEC, signaling a transition from a superfluid to an insulator. Surprisingly, for a wide range of V_d, *even in the insulating regime*, striking interference-like fringes are observed in the time of flight images after the atoms are released from both the trap and disordered potentials. We interpret the fringes as due to residual quantum coherence present in the disordered BEC. These fringes disappear when V_d is further increased to become comparable to the chemical potential, as the BEC breaks into multiple pieces with no phase coherence between them.

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Yong Chen
Rice University

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