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Quantum Hydrodynamics in Bose-Einstein Condensates

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Bose-Einstein condensates (BECs) provide us with unique means to study intriguing nonlinear behaviors in a quantum system. For example, when a BEC is set into rotation, vortices can form and arrange themselves in lattices. The observed vortex lattices provide evidence for the existence of a macroscopic wavefunction governing the dynamics. In the group of Eric Cornell at JILA, University of Colorado, we have recently extended our studies of quantum hydrodynamics by creating shock waves in rotating and non-rotating condensates. In these experiments quantum shock waves have been observed directly. Quantum shock waves differ from classical shocks because the Gross-Pitaevskii equation that describes the BEC dynamics admits no dissipation. Instead, quantum shock waves are governed by dispersive effects leading to new dynamical features. In this talk, I will highlight some of our recent experiments in the field of nonlinear BEC dynamics. In addition, I will report on the progress of a new BEC machine that is currently being constructed in my laboratory at WSU, Pullman.