Quantum hydrodynamics in ultracold atomic gases

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Abstract:

When atomic gases are cooled to temperatures close to absolute zero, they can enter a quantum degenerate regime in which the wavemechanical behavior of matter becomes apparent. Bosons can form a Bose-Einstein condensate, characterized by a large number of atoms being described by a single wavefunction. Fermionic atoms, in contrast, form a Degenerate Fermi sea in which only one atom is allowed to occupy a given quantum state due to the Pauli exclusion principle. Interatomic interactions as well as the Pauli principle can lead to intriguing nonlinear dynamics in these systems. In this talk I will describe our recent and ongoing experiments with Bose-Einstein condensates and Degenerate Fermi seas. In the condensates nonlinear dynamics are directly observed. Particular emphasis is put on the generation of dispersive shock waves as well as the formation of solitons in these systems. The behavior of the fermions is very different and shock waves, while predicted to exist, are more difficult to detect. This showcases the striking influence of quantum statistics that becomes apparent when matter changes from classical behavior at room temperature to quantum behavior near absolute zero.