Abstract for an Invited Paper
for the MAR10 Meeting of
The American Physical Society

Matter-wave Interference in Bose-Einstein Condensates: a dispersive hydrodynamics perspective[1]

PETER ENGELS, Washington State University

Bose-Einstein condensates (BECs) can show striking nonlinear dynamics marked by the formation of dispersive shock waves and soliton trains, and by the existence of stable and unstable fluid flow regimes. These phenomena are readily observed in our experiments. For example, when two initially separate condensates with large atom numbers collide in a magnetic trap, dispersive shock waves can develop and spread out through the entire merged condensate. For sufficiently low particle numbers, the dynamics are markedly different and the merging of two condensates leads to a uniform train of dark solitons. The soliton train is closely related to the trigonometric interference patterns observed when two freely expanding, nearly non-interacting condensates overlap. Indeed, a uniform mathematical description can be found that identifies a smooth transition from solitons in the initial, low-density overlap region to the soliton trains observed in our in-trap merging experiments [1]. This leads to a hydrodynamic perspective on matterwave interference. In this talk I will present our recent and ongoing experiments studying nonlinear dynamics in ultracold quantum gases. In addition to creating solitons and shock waves by merging trapped BECs, we also observe soliton and shock wave formation when crossing the BEC phase transition rapidly. The results for the bosonic case will be contrasted to the behavior of ultracold quantum degenerate Fermi clouds where shock waves are predicted to exist but appear to be more difficult to observe experimentally. The results also have implications for the behavior of bosons and fermions in the presence of disordered potentials that we produce e.g. using speckle potentials.

[1] M. A. Hoefer, P. Engels and J. J. Chang, Physica D 238, 1311 (2009)

[1]We acknowledge funding from NSF and ARO.