NWS12-2012-000080

Abstract for an Invited Paper
for the NWS12 Meeting of
the American Physical Society

Quantum hydrodynamics in dilute-gas Bose-Einstein condensates[1]

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The peculiar dynamics of superfluids are a fascinating research topic. Since the first generation of a dilute gas Bose-Einstein condensate (BEC) in 1995, quantum degenerate atomic gases have taken the investigation of quantum hydrodynamics to a new level. The atomic physics toolbox has grown tremendously and now provides unique and powerful ways to explore nonlinear quantum systems. As an example, pioneering results have recently revealed that the counterflow between two superfluids can be used as a well controlled tool to access the rich dynamics of vector systems. New structures, such as beating dark-dark solitons which only exist in multicomponent systems and have never been observed before, can now be realized in the lab for the first time. Furthermore, the field of nonlinear quantum hydrodynamics is entering new regimes by exploiting Raman dressing as a tool to directly modify the dispersion relation. This leads to the generation of spin-orbit coupled BECs, artificial gauge fields, etc. that are currently receiving tremendous interest due to their parallels to complex condensed-matter systems. Studies of quantum hydrodynamics help to develop a profound understanding of nonlinear quantum dynamics, which is not only of fundamental interest but also of eminent importance for future technological applications, e.g. in telecommunication applications using optical solitons in fibers. This talk will showcase some "classic" hallmark results and highlight recent advances from the forefront of the field.

[1]We acknowledge funding from NSF and ARO.