DAMOP11-2011-020022

Abstract for an Invited Paper
for the DAMOP11 Meeting of
the American Physical Society

Many-body physics with ultracold bosons in 1D geometry

ELMAR HALLER, Experimentalphysik Uni Innsbruck

I describe a series of experiments with quantum gases of strongly interacting atoms confined to one-dimensional (1D) geometry. The external confinement strongly affects the atomic scattering process and gives rise to a new type of scattering resonances, so-called confinement-induced resonances. One such resonance allows us to tune and dynamically control interparticle interactions in 1D and to access the regimes of strong repulsion or attraction. In particular, we observe the formation of a new highly-correlated quantum many-body phase called the Super-Tonks-Girardeau gas. This excited phase in 1D is stabilized in the presence of attractive interactions by maintaining and strengthening quantum correlations across the confinement-induced resonance. In a second experiment we drive a novel type of quantum phase transition, the "pinning transition," by adding a shallow periodic potential to a strongly-interacting 1D system. For sufficiently strong interactions, the transition is induced by adding an arbitrarily weak optical lattice along the longitudinal direction of the 1D system, leading to immediate pinning of the particles. We map out the phase diagram and find that our measurements in the strongly interacting regime agree well with a quantum field description based on the exactly solvable sine-Gordon model. We trace the phase boundary all the way to the weakly interacting regime where we find good agreement with the predictions of the 1D Bose-Hubbard model.