Abstract

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Frustrated Bose condensates in optical lattices

In this talk I will discuss Bose-condensed ground states of bosons in a two dimensional square optical lattice in the presence of frustration due an effective vector potential, for example, due to lattice rotation.

Bosonic atoms in optical lattices can display superfluid and Mott insulating phases. If the system is rotated then in the corotating frame, this is equivalent to introducing an effective magnetic field proportional to the rotation frequency. A vector potential introduces an Aharonov-Bohm phase for the boson hopping from site to site. The wave function is "frustrated" if the phase twists around each plaquette add up to $2\pi\alpha$ for some noninteger α. For a Bose condensate at low effective magnetic field this introduces vortices into the condensate. The presence of the optical lattice interferes with the formation of an Abrikosov vortex lattice and quantum fluctuations may be enhanced. Further, if the number of vortices becomes comparable to the number of bosons, the system may enter into a fractional quantum Hall (FQH) state. However this requires a very high rotation frequency or a low atomic density which is hard to achieve experimentally.

In this talk, I will focus on the experimentally accessible regime where a condensate still exists and discuss possible precursors to fractional quantum Hall states in a frustrated Bose condensate. I will present how quantum fluctuations affect the order parameter, off-diagonal long range order and the superfluid fraction for different degrees of frustration and for the whole range of incommensurate filling. I will show that for cases with fewer than 1/3 flux quantum per lattice plaquette the fractional condensate depletion increases as the system approaches the Mott phase giving rise to the possibility of a noncondensed state of FQH type before the Mott phase is reached.