Dynamical properties of bosons in an optical lattice with a synthetic magnetic field

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We study the dynamical properties of bosons in an optical lattice subject to a synthetic magnetic field at zero temperature. A synthetic magnetic field can be created through rotation of an optical lattice or Raman transition induced by a spatially-varying laser beam.
First, we consider a regime where a large number of bosons are occupied in each site of the optical lattice. Then, the dynamics is well described by the Gross-Pitaevskii equation. We describe the nonlinear dynamics of vortex nucleation in a Bose-Einstein condensate in a deep optical lattice. The detailed comparison with the recent experimental observation of the vortex nucleation will be reported.
Second, we study the effect of synthetic magnetic fields on quantum dynamics of bosons in an optical lattice under the hard-core limit. By solving the Heisenberg equation of motion for the annihilation operator, we find the periodic motion with the typical spatial period determined by the strength of the magnetic field. We also discuss the dynamics of usual bosons for comparison, revealing the effect of the hard core nature on the dynamics.