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Vortex Dynamics and Hall Conductivity of Hard Core Bosons
ASSA AUERBACH, Technion - Israel Institute of Technology, NETANEL LINDNER, California Institute of Technolgoy, DANIEL AROVAS, University of California at San Diego — Magneto-transport of hard core bosons (HCB) is studied using an XXZ quantum spin model representation, appropriately gauged on the torus to allow for an external magnetic field. We find strong lattice effects near half filling. An effective quantum mechanical description of the vortex degrees of freedom is derived. Using semiclassical and numerical analysis we compute the vortex hopping energy, which at half filling is close to magnitude of the boson hopping energy. The critical quantum melting density of the vortex lattice is estimated at 6.5x10-5 vortices per unit cell. The Hall conductance is computed from the Chern numbers of the low energy eigenstates. At zero temperature, it reverses sign abruptly at half filling. At precisely half filling, all eigenstates are doubly degenerate for any odd number of flux quanta. We prove the exact degeneracies on the torus by constructing an SU(2) algebra of point-group symmetries, associated with the center of vorticity. This result is interpreted as if each vortex carries an internal spin-half degree of freedom ('vspin'), which can manifest itself as a charge density modulation in its core. Our findings suggest interesting experimental implications for vortex motion of cold atoms in optical lattices, and magnet-transport of short coherence length superconductors.

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