MAR12-2011-001149

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

Circuit QED Simulation of Interacting Bosons with Microwave Polaritons[1]

STEVEN GIRVIN, Yale University

A polariton is a coherent superposition of a photon and an electronic excitation such as an exciton. Polaritons can have very low mass (associated with the photon component) and repulsive interactions (associated with the exciton component). Recent experimental progress has observed Bose-Einstein condensation and superfluidity in polaritons in semiconductor quantum wells. In this talk I will discuss the possibility that many-body physics and quantum phase transitions of interacting polaritons [1-3] can be observed in arrays of microwave resonators containing superconducting qubits [4-6]. If the qubits are not far-detuned from the cavities, the natural excitations are coherent superpositions of cavity and qubit excitations and they have interactions acquired from the anharmonicity of the qubits. These interactions can lead to quantum phase transitions in the limit of weak dissipation. It may even be possible to simulate the fractional quantum Hall effect for bosons by coupling the polaritons between sites using superconducting structures which act as 'circulators' that break time-reversal and charge-conjugation symmetry. In light of recent progress in achieving very long-coherence times for superconducting qubits and strong qubit coupling to microwave photons, experimental prospects for observing quantum phase transitions in microwave resonator lattices will be described.

[1] A. D. Greentree, et al., *Nat. Phys.* **2**, 856 (2006).
[2] M. J. Hartmann et al., *Nat. Phys.* **2**, 849 (2006).
[3] D. G. Angelakis, M. F. Santos, and S. Bose, *Phys. Rev. A* **76**, 031805 (2007).
[4] J. Koch and K. Le Hur, *Phys. Rev. A 80*, 023811 (2009).
[5] 'Time-reversal symmetry breaking in circuit-QED based photon lattices,'Jens Koch, Andrew A. Houck, Karyn Le Hur, and S. M. Girvin, *Phys. Rev. A* **82**, 043811 (2010).
[6] 'Synthetic gauge fields and homodyne transmission in Jaynes-Cummings lattices,' A. Nunnenkamp, Jens Koch, and S. M. Girvin, *New J. Phys.* **13** 095008 (2011).

[1]Work supported by the NSF, ARO, LPS and NSA. This work is a collaboration with Jens Koch, Karyn Le Hur, Andreas Nunnenkamp, Andrew Houck and Claudia DeGrandi.