MAS15-2015-000010

Abstract for an Invited Paper
for the MAS15 Meeting of
the American Physical Society

## Collective Phases of Strongly Interacting Cavity Photons

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Motivated by recent experimental advances with coupled arrays of non-linear photonic cavities, we study the steady state phases of the Bose-Hubbard model in the presence of dissipation and coherent driving. Using a site-decoupled mean-field approximation, we identify phases with antiferromagnetic and incommensurate density wave spatial order, in addition to limit cycle phases, where oscillatory population dynamics persist indefinitely. We also identify collective optically bistable phases, where the system supports two stable steady states among spatially uniform, antiferromagnetic, and limit cycle phases. Further, we employ exact quantum calculations for one dimensional arrays of cavities, using quantum trajectory and density matrix renormalization group methods. These methods produce phases with short-range antiferromagnetic and density wave correlations, agreeing surprisingly well with the mean-field predictions. Interestingly, the quantum trajectories simulations exhibit real-time collective switching between the classical steady states. We provide a clear physical picture for these dynamics, and relate the switching times to properties of the exact quantum density matrix.