Abstract Submitted
for the DAMOP16 Meeting of
The American Physical Society

Collective phases of strongly interacting cavity photons[1] RYAN M. WILSON, United States Naval Academy, KHAN W. MAHMUD, University of Maryland, ANZI HU, American University, ALEXEY V. GORSHKOV, National Institute of Standards and Technology, MOHAMMAD HAFEZI, University of Maryland, MICHAEL FOSS-FEIG, United States Army Research Laboratory — We study a coupled array of coherently driven photonic cavities, which maps onto a driven-dissipative XY spin-$\frac{1}{2}$ model with ferromagnetic couplings in the limit of strong optical nonlinearities. Using a site-decoupled mean-field approximation, we identify steady state phases with canted antiferromagnetic order, in addition to limit cycle phases, where oscillatory dynamics persist indefinitely. We also identify collective bistable phases, where the system supports two steady states among spatially uniform, antiferromagnetic, and limit cycle phases. We compare these mean-field results to exact quantum trajectories simulations for finite one-dimensional arrays. The exact results exhibit short-range antiferromagnetic order for parameters that have significant overlap with the mean-field phase diagram. In the mean-field bistable regime, the exact quantum dynamics exhibits real-time collective switching between macroscopically distinguishable states. We present a clear physical picture for this dynamics, and establish a simple relationship between the switching times and properties of the quantum Liouvillian.

[1]This research was supported in part by the NSF under Grant No. NSF PHY11-25915.

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Date submitted: 27 Jan 2016 Electronic form version 1.4