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Multi-mode Quantum Nonlinear Optics in Rydberg Atomic Ensembles FAN YANG, YONG-CHUN LIU, LI YOU, State Key Laboratory of Low Dimensional Quantum Physics, Department of Physics, Tsinghua University, Beijing 100084, China, DEPARTMENT OF PHYSICS, TSINGHUA UNIVERSITY TEAM — Optical nonlinearity at the single-photon level can facilitate photonic quantum information processing. Recent studies in Rydberg atomic ensembles indicate that strong and long-range photonic interactions can be created by mapping photons to Rydberg polaritons. This work develops a framework for interacting photonic polaritons in the multi-mode regime. The presence of nonlocal photon-photon interactions is found to destroy the energy or momentum matching conditions between distinct propagating polaritons, and consequently gives rise to blockaded coupling between them. Such a blockade mechanism protects the system from interaction-induced dissipation and enables highly tunable few-photon nonlinearities, which consequently facilitates the construction of single-photon quantum switch, deterministic generation of entangled photon pairs, as well as spin-exchange collisions between single-photons.

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