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Dispersive optical non-linearity at the single-photon level OFER FIRSTENBERG, Department of Physics, Harvard University, THIBAULT PEYRONEL, QI-YU LIANG, Department of Physics and RLE, MIT, ALEXEY GORSHKOV, Institute for Quantum Information and Matter, Caltech, MIKHAIL LUKIN, Department of Physics, Harvard University, VLADAN VULETIC, Department of Physics and RLE, MIT — Realizing and engineering optical non-linearity at the level of single photons is a goal of scientific and technological significance, pertaining to non-classical light sources, all-optical switches and phase gates, and correlated many-photon states. We obtain strong interaction between propagating photons by coupling them to high-laying Rydberg levels in an atomic gas. The resulting "Rydberg polaritons" possess a large electric dipole-moment and interact via the Van-der-Waals forces, while slowly traversing the medium. The interaction potential can be varied from real to imaginary; consequently, the dynamics of the two-photon wavefunction varies from dispersive (Schrodinger-like) to dissipative (diffusion-like). To characterize the final two-photon state, we use time-dependent tomography, and by that delineate the two-photon bound-state. We observe strong bunching and anti-bunching, and large conditional phase-shifts, with an effective interaction range much larger than the Van-der-Waals blockade range.

Ofer Firstenberg
Department of Physics, Harvard University

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