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Repulsive photon-photon interactions mediated by Rydberg atoms. SERGIO CANTU, Massachusetts Institute of Technology, ADITYA VENKATRAMANI, Harvard University, WENCHAO XU, Massachusetts Institute of Technology, LEO ZHOU, Harvard University, BRANA JELENKOVIC, University of Belgrade, MIKHAIL LUKIN, Harvard University, VLADAN VULETIC, Massachusetts Institute of Technology — The ability to control strongly interacting light quanta (photons) is of central importance in quantum science and engineering. Here, we demonstrate a method for coherent control of strongly interacting photons, extending quantum nonlinear optics into the domain of repulsive photons. This is achieved by coherently coupling photons using electromagnetically induced transparencies (EIT) to several atomic states, including strongly interacting Rydberg levels in a cold Rubidium gas. Using this approach we demonstrate both repulsive and attractive interactions between individual photons and characterize them by the measured two- and three-photon correlation functions. For the repulsive case, we demonstrate signatures of interference and self ordering from three-photon measurements. These observations open a route to study strongly interacting dissipative systems and quantum matter composed of light such as a crystal of individual photons.

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