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An enhanced Kerr non-linearity using Rydberg electromagnetically induced transparency outside the blockade regime (G)

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The strong interactions between Rydberg atoms provides an exciting platform for quantum nonlinear optics. Rydberg blockade (where a cloud of many atoms is unable to support more than a single excitation due to dipole interactions) combined with electromagnetically induced transparency (EIT) (where on-resonant absorption is suppressed due to the presence of a second coupling field) has been used to demonstrate single photon generation, strong photon-photon interactions, and quantum memory. Despite these advances, Rydberg blockade is unsuited for other important applications in quantum nonlinear optics, like quantum non-demolition measurements of photon number, and photon-number squeezing. This is because Rydberg blockade treats all photons after the first photon (which caused the blockade) indistinguishably. Here, we report on an experiment far from the blockade regime where weak Rydberg interactions enable an optical pulse propagating through a cloud of atoms to acquire a phase shift proportional to the number of photons in a second optical pulse. We present preliminary observations of the phase shift as a function of photon number and Rydberg principal quantum number. We discuss possible next steps towards harnessing this enhanced Kerr nonlinearity for photon-number squeezing and non-demolition measurement.

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