Abstract Submitted
for the DAMOP19 Meeting of
The American Physical Society

Observation of a large, resonant, cross-Kerr nonlinearity in a free-space Rydberg medium JOSIAH SINCLAIR, DANIELA ANGULO, NOAH LUPU-GLADSTEIN, KENT BONSMA-FISHER, AEPHRAIM M. STEINBERG, University of Toronto — Rydberg-Rydberg interactions combined with electromagnetically induced transparency (EIT) are an extremely promising platform for nonlinear optics at the level of single photons. In light of this, there have been concerted theoretical and experimental efforts endeavoring to harness the powerful interactions of Rydberg atoms to implement a Kerr nonlinearity. We report the experimental observation of an enhanced cross-Kerr nonlinearity in a free-space medium based on resonantly-excited, interacting Rydberg atoms and electromagnetically induced transparency. The nonlinearity is used to implement cross-phase modulation between two optical pulses. The nonlinear phase written onto the "probe" pulse is measured to be as large as 8mrad per nW of "signal" power, corresponding to a $\chi^{(3)}$ of $10^{-8}\,\mathrm{m^2V^2}$. The cross-Kerr nonlinearity scales with the adjusted principal quantum number like $\mathrm{n}^{5.6+/-0.4}$, consistent with our expectations for a van der Waals based nonlinearity. Our results have applications ranging from optical quantum information processing to quantum non-demolition measurement of photon number.

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Date submitted: 06 Feb 2019 Electronic form version 1.4