Abstract Submitted
for the DAMOP18 Meeting of
The American Physical Society

Progress towards an apparatus capable of studying strong optical nonlinearities using Rydberg Electromagnetically Induced Transparency

JOSIAH SINCLAIR, KENT FISHER-BOSMA, AEPHRAIM STEINBERG, University of Toronto — The strong dipole-dipole interaction between Rydberg atoms provides an exciting platform for quantum nonlinear optics. We report on progress towards studying various nonlinear effects at the single-photon level using Rydberg electromagnetically induced transparency (EIT). Our apparatus consists of a Rubidium magneto-optical trap (MOT), a "probe" beam at 780nm locked on resonance that can be modulated on and off quickly and scanned in frequency synchronously with the atom cycle, and a "coupling" beam at 480nm that is locked to a Rydberg transition using EIT spectroscopy and can be modulated asynchronously. The beams are overlapped and counter-propagated through the MOT cloud, and the transmission of the probe is recorded using an avalanche photodiode. We observe EIT at low n (n=50), where the interaction length scales are small compared to the atom cloud size and beam focus. With the addition of a crossed optical dipole trap to match the atom cloud size to the same length scale as the interactions, we will be able to study photon-photon interactions via Rydberg EIT. An intermediate goal is to study weak nonlinearities in a non-blockaded regime for number state squeezing as an exploratory step toward a quantum-non-demolition measurement of photon number.

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Date submitted: 06 Feb 2018 Electronic form version 1.4