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Cooperative optical non-linearity due to dipolar interactions in an ultra-cold Rydberg ensemble

Rydberg refers to states with high principal quantum number, n, which have large dipole moments ~ n^2. Atom-light interactions with Rydberg atoms can be used to induce large optical non-linearities on a probe field either from enhanced electric field sensitivity [1] or due to dipole-dipole interactions [2]. These are realized using electromagnetically induced transparency (EIT) to generate a dark state in the medium, composed of a superposition of ground and Rydberg states [3]. Following on from previous work on Rydberg EIT on cold atoms [4] the system ^{87}Rb $5S_{1/2} \rightarrow 5P_{3/2} \rightarrow nS_{1/2}$ has been investigated to look for signatures of dipoledipole induced non-linearity as the probe field is increased above the weak probe limit. This is compared to a pair model for two three-level atoms interacting via a dipole coupling of the Rydberg states. Results show a suppression of transparency on resonance due to a cooperative non-linearity. This could be used to map atomic interactions onto the photon field, the first step towards realising a photonic phase gate.

[1] A. K. Mohapatra et al., Nature Phys. **4**, 890 (2008).
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[3] A. K. Mohapatra, T. R. Jackson, and C. S. Adams, Phys. Rev. Lett. **98**, 113003 (2007).
[4] K. J. Weatherill et al., J. Phys. B **41**, 201002 (2008).

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