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Dynamics of Rydberg spin waves in atomic ensembles[1]
FRANCESCO BARIANI, Y.O. DUDIN, A. KUZMICH, T.A.B. KENNEDY, School of Physics, Georgia Institute of Technology — We study the excitation, interaction and retrieval of collective excitations (spin waves) of Rydberg levels in large, optically thick atomic ensembles. Rather than assuming a Rydberg blockade mechanism, multiple Rydberg level excitations are allowed to mutually interact and dephase. We describe how dipole-dipole interactions destroy the correlations between spin waves leading to isolation and manipulation of individual excitations. Optical retrieval in a phase-matched direction shows the suppression of correlation. The dephasing process is suitable for the fast creation of high quality single photons with maximum efficiency $1/e$. Individual excitations can be stored in separate weakly-interacting Rydberg levels and later entangled by applying a dedicated dephasing scheme. This mechanism is shown to have a favorable, approximately exponential, scaling. Strong dipole-dipole interactions required to speed up the protocol can be generated by mixing adjacent, opposite-parity Rydberg levels with a microwave field. This resonant coupling ($ns+n'p \rightarrow n'p+ns$) extends the $1/r^3$ interaction over the whole ensemble, while short range Van der Waals channels ($ns+ns \rightarrow np+(n-1)p$) decay as $1/r^6$.

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