Nonlinear Optics with Rydberg excitations

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Coupling light to ensembles of strongly interacting particles has emerged as a promising route toward achieving optical nonlinearities at the few-photon level. One specific way to implement such nonlinearities is to interface light with Rydberg atoms by means of electromagnetically induced transparency, which entails freely propagating photons with synthetic interactions.
In the two lectures we will review the underlying theoretical concepts behind Rydberg-EIT. Starting from a classical picture we will consider simple few-body situations and respective applications and discuss interaction effects in the multiphoton regime. Particular emphasis will be placed on the effects of dissipation and alternative approaches to suppress photon losses for quantum photonics applications applications.