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Non-linear optics using Rydberg atoms

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We present recent work on cooperative non-linear optics where the non-linearity is mediated not directly by the interaction between light and matter, but indirectly by dipole-dipole interactions between light induced excitations. For the giant dipoles associated with transitions between highly excited Rydberg states, a single excitation induces a cooperative response of up to 1000 neighboring atoms, thereby greatly amplifying the effect of each photon. This amplifying mechanism results in strongly enhanced optical non-linearities, see J. D. Pritchard *et al.* Phys. Rev. Lett. **105**, 193603 (2010), allowing the creation and control of non-classical states of light.