

Quantum-optical nonlinearities induced by Rydberg-Rydberg interactions: A perturbative approach

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Author(s):

A. Grankin, E. Brion, E. Bimbard, R. Boddeda, I. Usmani, A. Ourjoumtsev & P. Grangier

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In this article, we theoretically study the quantum statistical properties of the light transmitted through or reflected from an optical cavity, filled by an atomic medium with strong optical nonlinearity induced by Rydberg-Rydberg van der Waals interactions. Atoms are driven on a two-photon transition from their ground state to a Rydberg level via an intermediate state by the combination of a weak signal field and a strong control beam. By using a perturbative approach, we get analytic results which remain valid in the regime of weak feeding fields, even when the intermediate state becomes resonant thus generalizing our previous results. We can thus investigate quantitatively new features associated with the resonant behavior of the system. We also propose an effective nonlinear three-boson model of the system which, in addition to leading to the same analytic results as the original problem, sheds light on the physical processes at work in the system.

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