Enhancing interactions in hot vapor

Ohr Lahad[1], Omri Davidson[1], Ran Finkelstein[1], Ohad Michel[1], Ofer Firstenberg[1]

[1] Department of Physics of Complex Systems, Weizmann Institute of Science, Herzl St 234 Rehovot, Israel

The optical depth (OD) of a medium is the resource for many applications in optics. Specifically, for quantum-nonlinear processes such as the Rydberg blockade, the governing parameter is the OD of a confined interation region [1]. In hot vapor, the Doppler broadening of lines due to thermal motion has been well-studied. However, the accompanied decrease of cross-section has not received much attention. Doppler-free techniques are typically velocity-selective and therefore remain with low OD. This reduction of the OD has so-far hindered the observation of the Rybderg blockade in hot vapor. We demonstrate a method for retrieving the lost OD. The Raman resonances of different atomic velocities are merged by a velocity-dependent light-shift from a compensating beam [Fig. 1(a)]. All velocities absorb photons at a single resonant frequency, thereby surpassing the "hot OD" limit. In addition, we have recently shown how the total OD of a system can be utilized to increase quantum-nonlinear interactions [2]. In this theoretical work, we induce an effective cavity on the quantum-state of the atoms [Fig. 1(b)]. These methods pave the road towards realization of the Rydberg blockade in hot atoms.

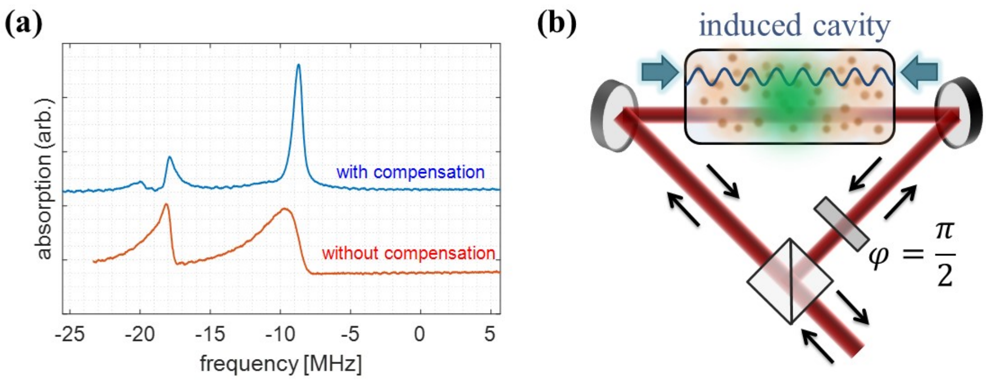

Figure 1. Methods for increasing the absorption cross-section. (a) Doppler compensation: two-photon Raman absorption (red) is enhanced by applying a compensating beam (blue). (b) By inducing a periodic shift in the atomic quantum state, an effective cavity can be generated, increasing the intensity of photons in the medium.

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[2] O. Lahad and O. Firstenberg, Induced cavities for photonic quantum gates, PRL **119**, 113601 (2017).