Collective suppression of light scattering in a cold atomic ensemble

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When resonant emitters, such as atoms, molecules, or quantum dots, with a transition at a wavelength λ are confined inside a volume smaller than λ^3, they are coupled via strong dipole-dipole interactions. In this regime, the response of the ensemble to near-resonant light is collective and originates from the excitation of collective eigenstates of the system, such as super- and sub- radiant modes [1,2]. Dipole-dipole interactions profoundly affect the response of the system, as they modify the decay rate and shift the energy of each state in a different way, leading, e.g., to the collective Lamb shift [3,4]. The collective scattering of light can strongly differ from the case of an assembly of noninteracting emitters [5] and has been predicted to be suppressed for a dense gas of cold two-level atoms [6].

Here, I will present the first observation of the collective suppression of light scattering by a cold sample of ^{87}Rb atoms with a size comparable to the wavelength of their optical transition [7]. Starting from a single atom and gradually increasing the number of atoms up to a few hundreds, we observe the emergence of a strong collective suppression of light scattering due to the increasing dipole-dipole interactions. Consistently with this suppression, we observe a broadening of the optical transition at $\lambda = 780$ nm as well as a small red shift. We find that our measurements are compatible with numerical simulations of the response of the system in the low excitation limit, accounting for all the scattering processes between atomic dipoles and the internal level structure of the atoms. Ongoing investigations of the temporal response of the system, and comparisons to the case of a single atom [8], should also provide insight into the interplay between dipole-dipole interactions and collective scattering.

References

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