Superradiant dynamics in dilute cold atomic clouds

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Abstract

We study experimentally and numerically the superradiant dynamics of a dilute cold atomic clouds driven by a weak laser beam (linear-optics regime).
Superradiance generally refers to the accelerated radiation rate of a collection of excited atoms due to the collective interaction of the sample with light and the vacuum reservoir [1]. However superradiance is still observable in the linear-optics regime, when there is only one quantum of excitation shared among the atoms [2,3]. How can we understand superradiance in this case?

Recent studies showed that we could describe superradiance with an "optical" model called linear-dispersion theory [4,5]. In this model, based on a single scattering event embedded in an effective medium, we can interpret superradiance as a dispersion effect associated with the scattering and propagation through the sample.

Our goal now is to show a non-intuitive phenomenon, predicted by the linear-dispersion theory, which is that the superradiant decay rate can be made larger by smoothing the laser switch-off. In other words the collective atomic decay rate is a non-monotonous function of the switch-off duration of the driving laser: the maximum decay rate is not obtained for the fastest laser switch-off. This study led us to a better understanding on what is the physical nature of superradiance in the linear-optics regime.

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