Super- and subradiance in a large cloud of cold atoms

Michelle O. Araújo*[1,2], Patrizia Weiss[1], Ivor Krešić[3], William Guérin[1], and Robin Kaiser[1]

[1]Institut de Physique de Nice – Université Nice Sophia Antipolis [UNS], CNRS : UMR7335, Université Nice Sophia Antipolis (UNS) – France

[2]CAPES Foundation, Ministry of Education of Brazil, Brasília, DF 70040-020, Brazil – Brazil

[3]SUPA and Department of Physics, University of Strathclyde, Glasgow G4 0NG, Scotland, United Kingdom – United Kingdom

Abstract

The problem of the interaction of N particles with a laser beam and vacuum modes can give rise to many interesting phenomena concerning the spontaneous emission of light and its propagation in the medium. The cooperative effects, for example, like super- and subradiance, are effects related to the coherence created between the particles when a photon is emitted spontaneously from a single excited particle. Superradiance can be dened as the enhancement of the spontaneous emission due to constructive interference of the scattered light. Its counterpart, subradiance, is the trapping of some remaining light due to destructive interference.

In cold atoms, some previous theoretical works predict and characterize these two cooperative effects in a large and dilute cloud, in the regime of weak intensities and large detuning of the driving laser. The theoretical model is a coupled-dipole model for two-level atoms at single excitations. The experiment consists in measuring the super- and subradiant decay rates from the temporal emitted power after the switch-off of the laser in the steady state.

In this work, we report the experimental observation of super- and subradiance in a large cloud of cold atoms [1, 2]. For subradiance, the main result is the linear scaling with the optical thickness of the cloud and its independence with the detuning. For superradiance, off-axis superradiance is observed, i.e., the superradiance out of the forward direction. We check the validity of our measurements from the predictions of the coupled-dipole model. Finally, we discuss our more recent works: a setup of phased cloud to control the subradiant amplitude emission [3] and the interplay of subradiance with radiation trapping [4].

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*Speaker