Influence of dipole-dipole interatomic interactions on the process of spontaneous decay of an atom embedded in a cold atomic cloud

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The problem of spontaneous emission of an atom embedded inside a dielectric, or an atom located near a condensed surface has attracted considerable interest. By now several theoretical models are used for description of the local field correction of the decay rate of such an atom. Most theoretical studies of this problem are based on a macroscopic approach. Starting from the approximation using Fermi's golden rule [1] several more accurate macroscopic models were suggested [2]. There were several attempts to describe the influence of the environment on spontaneous decay microscopically [3,4] (and references therein).

In this presentation we report theoretical analysis of local field corrections to the spontaneous decay of an atom inside the cold atomic ensemble and an atom located near its surface. We consider dense atomic clouds, in which the average interatomic distances are comparable with the optical wavelength. Our quantum microscopic approach is based on the non-steady state Schrödinger equation for the wave function of a combined system consisting of atoms and the electromagnetic field generated in the process of the system evolution [5]. Elimination from consideration states with excitation in the field subsystem leads us to a finite set of equations for the state amplitudes of a multi atomic system in which coupling between atoms is described by the so-called "matrix of reemission". The amplitudes of quantum states of the considered system are calculated numerically, which allows us to analyze multi-exponential spontaneous decay dynamics. We do not restrict ourselves by a scalar model of the field and do not introduce model of continuous media. This gives us possibilities to describe correctly interatomic interactions and to take into account disorder of the atomic cloud.

In specific calculations, we focus our attention towards the dependence of the local field correction on the differences in the properties of the embedded atom and atoms in the environment as well as on the density of the atomic cloud.

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