universität innsbruck

Department of Theoretical Physics

Theory Colloquium

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"Light-matter interface based on collective and cooperative effects"

Abstract

Understanding and control of light-matter interactions have been central to the development of modern physics. A promising approach for study of such interactions is based on ensemble of neutral atoms. Manipulations with density and spatial organization of atoms in a system can bring fascinating results, which are interesting for quantum information applications. For example, reducing average distance between atoms up to resonant wavelength induces dipoledipole interaction and results in cooperative effects. These effects in spatially dense atomic ensembles can modify optical properties of the system. Moreover, spatial organization of atoms in ordered arrays and optical lattices causes a manifestation of collective effects. In such systems, long-range spatial order brings dramatic consequences for the light propagation.

Collective and cooperative effects manifistable in an atomic ensemble could provide essential enhancement of the coupling strength between the light and atomic systems. Moreover, recent experimental advances in the trapping technique have made it possible to create 1D, 2D or 3D spatially ordered atomic configurations, where the collective effects play a very important role. In addition, the interaction between light and atoms can be enhanced by trapping atoms in the vicinity of a nanoscale waveguide due to strong confinement of the light.

In this talk, I will discuss light propagation in an atomic ensemble where average distance between atoms is comparable with the resonant wavelength. I will consider the light propagation in both free space and trapped near a nanofiber surface atomic ensembles. The light scattering in such dense atomic configuration is described in terms of microscopic approach based on the standard scattering matrix and resolvent operator formalism. We show theoretically and experimentally that spatially dense atomic ensembles allow obtaining effective light-matter interface and reliable light storage with essentially fewer atoms than it can be achieved in dilute gases. Furthermore, we show that the presence of an optical nanofiber modifies the character of atomic interaction and results in long-range dipole-dipole coupling between atoms not only via the free space, but also through the waveguide mode.

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