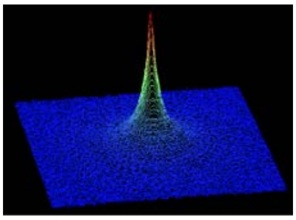

INLN UMR 6618 CNRS

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COOL PhD Project in Nice

In this research project we propose to approach the regime of strong scattering of light in a sample of laser cooled atoms with a new method, namely to add gain to the medium to create a random laser with cold atoms. In the past years we have extensively studied multiple scattering of light in cold atomic vapours in the passive regime. We have measured incoherent radiation trapping with trapping times up to 50 times the natural life time of the excited state of the atoms. More interestingly, we have studied coherent multiple scattering as shown by the observation of coherent backscattering, which is manifested by an enhanced averaged scattered intensity around the backward direction when the sample is illuminated by a weak probe laser. Since the first observation of coherent backscattering in 1999, we and others have studied a variety of effects connected to the specific properties of these atomic systems and we also identified some fundamental ingredients which can have a dramatic impact on the quantum phase transition to Anderson localization. Among the most interesting features one can mention the role of the ground state structure of the atoms, the inelastic and non linear effects for larger intensities of the probe light and magnetic field effects.

All the above mentioned experiments performed on laser cooled samples are done in the so-called dilute regime, where even for a large optical thickness necessary for multiple scattering to occur, the atomic density is so low, that recurrent scattering can be neglected. This is the case when the mean fee path l is large: $kl \gg 1$ (where k is the wavevector of the propagating light) and two successive scattering events happen in the far field ($l \gg \lambda$). The present PhD project will focus on obtaining a dense sample of cold atoms ($kl \approx 1$) to approach the regime of Anderson localization in passive media, using quasi-resonant dipole traps.

Cold atoms are good candidates to investigate the photon statistics and temporal intensity correlations in these different regimes. In order to prepare our understanding of the photon statistics in systems with gain ('random laser'), we will first focus on the intensity statistics of a passive system, in both dilute and dense media. One important quantity in laser theory is the time intensity correlation function $g_2(t)$. We will thus study the behaviour of this quantity for a passive system of cold atoms under laser illumination. For a dilute system e.g., we expect to observe a regime similar to diffusing-wave spectroscopy, in which interferences along a given multiple scattering light path play an important role. The intensity fluctuations will be generated by the motion of atoms in the trap. Using balanced detection schemes as used in squeezing experiments, we will investigate the quantum limit (shot noise) of DWS. This technique will then be used to study the approach of the phase transition to Anderson localization.

Collective effects on the atomic motion can produce (classical and possibly quantum) correlations between atoms resulting in either self-structured or plasma physics type effects, which will have to be taken into account for a quantitative understanding of multiple scattering of photons in optical thick sample of cold atoms.

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Submission deadline : June 15th 2007

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

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