Dynamics of matter waves in random potentials: diffusion, localization, interactions

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In the last decades, the field of atom optics has allowed for accurate experimental investigations of transport and interference phenomena with cold atoms. In this context, the physics of interacting and non-interacting waves in disordered environments can today be finely studied, using tunable atomic matter waves in well controlled optical random potentials.

After briefly introducing the main concepts of atom optics in random optical potentials, I shall address the problem of the out-of-equilibrium evolution of a non-interacting matter wave in a speckle potential. The discussion will be focused on a recently proposed setup where interference phenomena such as coherent backscattering (weak localization) or coherent forward scattering (strong, Anderson localization) are probed in the distribution of atomic momenta. In the second part of the talk, I shall complicate the scenario by adding weak atomic interactions. As they couple atomic energies, interactions induce a thermalization process which causes the momentum distribution to converge toward a thermal equilibrium state, analog to what is seen in the context of weak wave turbulence. Under certain initial conditions and certain values of the disorder strength, a large-scale structure, a "condensate" , can appear in the equilibrium momentum distribution.