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Ultracold atoms in disordered optical lattices

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Fifty years ago, Nobel Prize winner P. W. Anderson predicted that the presence of disorder in a crystalline solid could stop the electronic flow, leading to a localization of the electrons and turning a metal into an insulator. We have use ultracold ^{39}K atoms in disordered crystals made of laser light in order to quantum-simulate the propagation of electrons in a disordered solid [1]. By tuning the amount of disorder in the lattice we observe the transition from a conducting state to an insulator characterized by absence of diffusion and exponential localization, as originally conjectured by Anderson. The possibility to modify the collisions between the particles via magnetic Feshbach resonances opens to the experimental study of the localization transition in the presence of interactions, which still poses open problems in condensed-matter theory. We will discuss the state of the ongoing research at LENS and the possibility of studying novel quantum phases in different interaction regimes, also in connection with the development of new diagnostic techniques for quantum gases in optical lattices.

[1] G. Roati et al., *Nature* **453, 895 (2008).**