Weak and strong localization in disordered systems

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Within a Boltzmann picture, non-interacting quantum particles in disordered media propagate according to a diffusive motion, which can be interpreted as a random walk through the defects of the material. When the coherence of particles is preserved however, the multiply scattered de Broglie waves interfere destructively. In general this leads to a reduction of the diffusion coefficient, a phenomenon known as weak localization. At strong enough disorder, the diffusion coefficient can even vanish and transport comes to the halt. This is the threshold of Anderson —or strong— localization.

In the lecture, I will first briefly discuss Anderson localization through its historical and phenomenological scaling description, and then present a microscopic approach known as the self-consistent theory of localization. Although approximate, the self-consistent theory is relatively accessible and accurate. It is also very flexible, for instance providing predictions for experimental problems as different as the conduction of electrons in dirty metals, the propagation of photons in complex dielectric structures or the motion of atoms subjected to random optical potentials. A large part of the lecture will be also devoted to the discussion of recent experimental and theoretical developments in the field, as well as of open questions.

Suggested references

1. "Fifty years of Anderson localization", edited by E. Abrahams (World Scientific Press, 2010).
2. E. Akkermans and G. Montambaux, "Mesoscopic Physics of electrons and photons", Cambridge University Press (2007).
3. Dossier Localisation d’Anderson (in French) in Images de la Physique 2009, http://www.cnrs.fr/publications/imagesdelaphysique/2009.htm