Cold atoms in optical lattices

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Ultracold atomic gases in optical lattices have emerged as an ideal experimental platform for studying condensed-matter physics in a clean and highly controlled environment. These systems can be used to realize extremely pure "materials" where the electrons of a solid are replaced by ultracold atoms, and the ion crystalline structure by the trapping potential created by interfering laser beams. In this lecture I will start introducing the basic concepts: the generation of the optical lattice, a review of the physics of a single particle in a periodic potential and the derivation of the effective lattice models. I will then discuss some many-body physics problems that have been studied in this setting, both in the case of bosonic and fermionic atoms. Some of the experimental techniques used for preparation and detection will be presented as well.

Recommended reading:

1. M. Greiner and S. Fölling*, Condensed-matter physics: Optical lattices*, Nature **453**, 736-738 (2008).
2. I. Bloch, *Strongly correlated quantum phases of ultracold atoms in optical lattices*, Proceedings of the International School on Physics Enrico Fermi 2006, Ultracold Fermi Gases (eds. Inguscio, M., Ketterle, W. & Salomon, C.) 715-749 (IOS Press, Amsterdam, (2007)).
3. T. Esslinger, *Fermi–Hubbard physics with atoms in an optical lattice*, Annu. Rev. Condens. Mater. Phys. **1**, 129–152 (2010).