Ultracold quantum gases in optical lattices

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I will present the physics of ultracold quantum gases in optical lattices, emphasizing the regime of very low temperatures and strong interactions. For bosons, a quantum phase transition takes place from a superfluid phase to a Mott insulator phase with drastically different coherence and transport properties. I will review experimental studies of these phases, where many-body properties are revealed by novel techniques often borrowed from quantum optics. These experiments provide a new perspective on many-body systems, complementary to condensed matter experiments, where the emphasis is traditionnally on transport and scattering of probe particles. I will discuss prospects to realize more complex quantum many-body phases. Current experiments are limited by finite temperatures and heating, and novel cooling methods applicable for ultralow (nK or below) temperature gases are sorely needed. I will review proposals and initial experiments in this direction.