Optical lattices, a quantum simulator for many-body physics

By

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Abstract:
Optical lattices are quantum gases arranged in synthetic lattices formed by light. They provide a new context to study many body physics with unprecedented control and precision. The successful emulation of the Hubbard model in optical lattices has stimulated world wide efforts to extend their scope to also capture more complex, incompletely understood scenarios of many-body physics, possibly relevant in condensed matter systems. I will discuss two possible paths in this direction. I will first present our recent experimental observations of superfluidity in higher bands of optical lattices, where orbital degrees of freedom play an essential role as in many condensed matter systems of interest, such as transition metal compounds. I will then discuss how periodic driving can be used to mimic the action of the Lorentz force upon electrons with neutral atoms in an optical lattices thus permitting the implementation of artificial magnetic fields. I will show that new scenarios become accessible in optical lattices such as the Bose-Hubbard model with complex tunneling, if bosons are used. For fermions a Dirac-like single particle dispersion as in Graphene or unconventional superfluidity with RVB-type BCS-pairing can be simulated.