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Artificial Staggered Magnetic Field for Ultracold Atoms in Optical Lattices[1]

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Uniform magnetic fields are ubiquitous in nature, but this is not the case for staggered magnetic fields. In this talk, I will discuss an experimental set-up for cold atoms recently proposed by us [1], which allows for the realization of a "staggered gauge field" in a 2D square optical lattice. If the lattice is loaded with bosons, it may be described by an effective Bose-Hubbard Hamiltonian, with complex and anisotropic hopping coefficients. A very rich phase diagram emerges: besides the usual Mott-insulator and zero-momentum condensate, a new phase with a finite momentum condensate becomes the ground-state at strong gauge fields [2]. By using the technique of Feshbach resonance, the dynamics of a coherent superposition of a vortex-carrying atomic condensate and a conventional zero-momentum molecular condensate can also be studied within the same scheme [3]. On the other hand, if the lattice is loaded with fermions, a highly tunable, graphene-like band structure can be realized, without requiring the honeycomb lattice symmetry [2]. When the system is loaded with a mixture of bosons and two-species fermions, several features of the high-Tc phase diagram can be reproduced. A dome-shaped unconventional superconducting region arises, surrounded by a non-Fermi liquid and a Fermi liquid at low and high doping, respectively [4].

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[2] Lih-King Lim, A. Hemmerich, and C. Morais Smith, Phys. Rev. Lett. 100, 130402 (2008), Phys. Rev. A 81, 023404 (2010).
[3] Lih-King Lim, T. Troppenz, and C. Morais Smith, arXiv:1009.1471.
[4] Lih-King Lim, A. Lazarides, A. Hemmerich, and C. Morais Smith, EPL 88, 36001 (2009) and Phys. Rev. A 82, 013616 (2010)

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