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Title: Topological quantum matter with ultracold gases

Abstract: Ultracold gases have become a competitive platform for the quantum simulation of many-body systems and already operate in regimes that are highly challenging for currently available theoretical and numerical methods. Moreover, they offer an unmatched flexibility in engineering the lattice structure, the coupling between different internal degrees of freedom (hyperfine atomic states) and the interparticle interactions. It is also easy to introduce in a controlled manner external time-dependent perturbations and to observe the resulting unitary dynamics. This has stimulated a lot of theoretical and experimental work in the field of quantum physics out of equilibrium. One of the most outstanding achievements in the field of ultracold gases has been the realization of lattice models with a topological nontrivial band structure [1][2], such as the Harper-Hofstadter model [3][4] and the Haldane model [5] and the observation of topological effects in the time evolution, such as the Thouless pump [6][7][8]. In this talk, I will review the topological classification of the single-particle band structure in terms of invariants such as the winding number and the Chern number [9], and explain the key experimental advances that have allowed to realize topological nontrivial bands for ultracold gases. Finally I will give a glimpse of the current frontier, the perspective of observing phases with intrinsic topological order and fractionalized excitations [2][10][11]. In particular ultracold gases would allow to realize for the first time fractional quantum Hall states for bosonic particles [11][12].

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