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Quantum gases and condensed matter

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GDR gaz quantiques

Ultracold atomic gases are by now recognized as an important platform of modern condensed matter physics. Feshbach resonances, optical lattices, and Rydberg excitations allow cold-gas experiments to explore widely different regimes, from weak interactions to the strongest possible ones. More generally, cold atoms are arguably the most flexible playground for the quantum simulation of many-body physics, with the potential of scalability towards regimes that are numerically intractable.

A wide variety of physical phenomena from condensed matter can be investigated experimentally with cold gases, which are accurately described by simple Hamiltonians with adjustable parameters, greatly facilitating a direct comparison with theory. These include, for example, the BEC-BCS crossover, the BKT transition in 2D gases, Mott insulators and antiferromagnetism, topological matter, spin liquids, Anderson and many-body localization... Measurement tools are diversifying and gaining in precision, whether it involves imaging atoms in situ, measuring their momentum distribution or even accessing dynamical response functions. Cold gases also allow one to study many-body phenomena far beyond conventional condensed matter physics, e.g. out-of-equilibrium dynamics induced by a quantum quench or an external driving, leading to the appearance of massively entangled quantum many-body states. Experimental advances stimulate theoretical developments, whether in the field of effective descriptions, approximations, physical concepts, or numerical methods, including in regimes of strong correlations.

This mini-colloquium will allow theorists and experimentalists working in different branches of quantum gases and condensed matter to discuss fundamental phenomena in quantum many-body physics, as well as methodological advances.

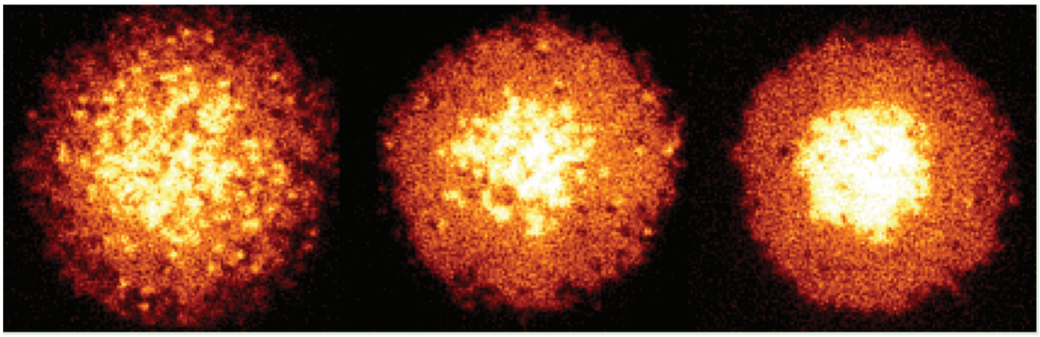

Figure: Detecting the number of atoms per site of an optical lattice (brightness) allows the observation of a Fermi gas turning from (left) a strongly correlated metal into (right) a band insulator surrounded by a fermionic Mott insulator [Phys. Rev. Lett. 125, 113601 (2020)]