Prospects for engineering anyons with ultracold atoms

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Anyons are exotic particles, which differ from bosons and fermions in their statistical phase under exchange of two particles. They arise as quasi-particle excitations in fractional quantum Hall systems, but their direct observation is still challenging. A promising approach for microscopic access to anyons is the quantum simulation of the fractional quantum Hall effect with ultracold atoms. In these systems, the large magnetic field can be created via a rapid rotation of a harmonic trap and the strongly-correlated states can be probed via single-atom resolved imaging. The Laughlin state of small systems can be adiabatically prepared by reaching rotation frequencies close to the centrifugal limit. Different protocols to probe the fractional statistics of the quasihole excitations have been proposed, including a spectroscopic signature by removing an atom into a different internal state or an interferometric signature by manipulating two quasiholes with optical tweezers. An alternative approach is the realization of the anyon-Hubbard model via a mapping to bosons with density-dependent Peierls phases. In this talk, I will present these ideas and discuss the experimental challenges and requirements on the way to a direct observation of anyons.

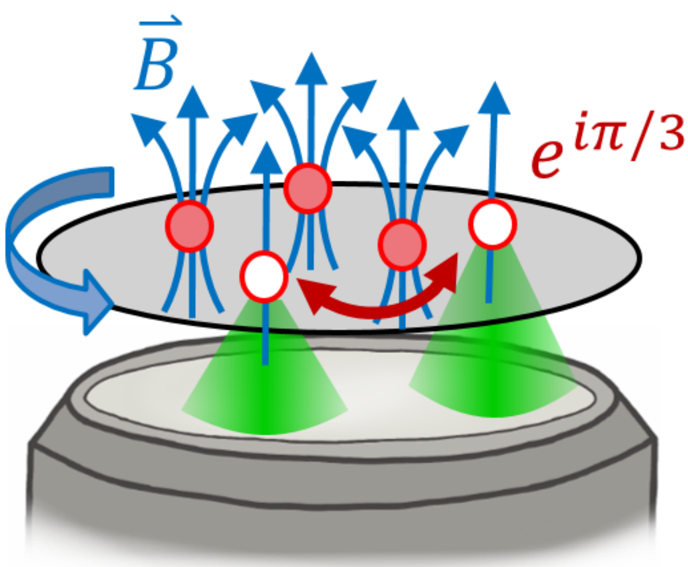

Figure 1: Illustration of the cold atom approach to engineer anyons. The effective magnetic field B realized via a trap rotation leads to magnetic fluxes (blue arrows), which attach to the fermionic atoms (closed red circles) in the strongly-correlated system. Near a fractional filling of atoms per flux quanta, additional flux quanta correspond to quasihole excitations with fractional charge and fractional exclusion statistics (open circles). They could be probed by direct manipulation with optical tweezers (green cones) using a high-resolution objective.