Simulating Anyonic Statistics in Few-Body Dynamics

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Quasiparticles with anyonic quantum statistics most prominently appear as the excitations of topologically ordered materials. Controlling and probing such excitations individually is an outstanding challenge for fundamental and applied physics.

Ultracold atoms offer opportunities to study anyonic statistics even outside of scenarios where they naturally occur. A promising approach to simulated anyonic behaviour in one dimension is to endow bosonic particles with a occupation-dependent tunneling phase. Such conditional tunneling events can be engineered in optical lattices by time-dependent driving. Clear effects of anyonic statistics should be observable in few-body systems of ultracold atoms, where quantum states can be initialized deterministically and microscopic observables including particle-resolved correlation functions can be measured.

I will show experiments on one-dimensional Bose-Hubbard chains that demonstrate all ingredients to perform simulations of anyonic dynamics. Within this approach, occupation-dependent tunneling is induced by amplitude modulation of an optical lattice in the presence of a potential gradient. We observe occupation-dependent tunneling in the driven system. In the same experimental setting, dynamics can be probed in quantum walks, where particles expand from an initially localized state. The time evolution of the density and correlation functions reveals the underlying statistics of the particles. Numerical calculations show that quantum walks with occupation-sensitive tunneling will show strong signatures of effective anyonic statistics.