Spin-resolved microscopy of SU(N) Fermi-Hubbard systems

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Quantum-gas microscopes provide direct access to the phases of the Hubbard model, offering microscopic insight into the interplay between interactions, magnetism, and doping. While most experiments have focused on SU(2) systems, alkaline-earth(-like) fermions extend this paradigm by enabling higher-symmetry SU(N) Hubbard models, leading to rich and largely unexplored phase diagrams. Despite their fundamental interest, a microscopic investigation of SU(N) quantum systems has remained challenging.

In this talk, I will present our recent realization of a quantum-gas microscope for fermionic ^{87}Sr, which features a nuclear spin I = 9/2 and thus supports SU(N≤10)-symmetric interactions. Our imaging scheme, based on cooling and fluorescence on strontium's narrow intercombination transition, enables spin-resolved, single-site detection. By implementing a spin-selective optical pumping protocol, we determine the occupation of all ten nuclear-spin states within a single experimental realization, providing a key capability for probing site-resolved magnetic correlations and accessing arbitrary spin–spin correlators.

We benchmark our method by observing single-particle Larmor precession across the full spin-9/2 ground-state manifold. In addition, we identify trap-induced Raman off-resonant scattering as the main limitation to imaging performance, a process that is also relevant for optical atomic clocks and future quantum computing platforms exploiting the large spin manifold of ^{87}Sr. We mitigate its detrimental effects through additional optical pumping during imaging, resulting in fidelities fully adequate for probing many-body magnetic phases.

These results establish ^{87}Sr quantum-gas microscopy as a powerful and versatile tool for the microscopic study of strongly correlated SU(N) systems, opening new avenues for exploring exotic magnetism as well as other applications in quantum simulation, computation, and metrology.

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