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Insights into quantum many-body systems through Hamiltonian reconstruction

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Unveiling the microscopic origins of quantum many-body phases dominated by the interplay of spin and charge degrees of freedom constitutes one of the central challenge in modern strongly correlated many-body physics. When holes hop through a background of insulating spins, they displace their positions, which in turn induces effective frustration in the magnetic background. However, the precise quantification of this effect in a quantum many-body system is an extremely challenging task.

We use Hamiltonian learning schemes to associate the hole-removed spin background with a purely magnetic Hamiltonian. This approach allows us to quantify the effect of the hole-motion on the spin background, using Fock space snapshots at intermediate temperatures, readily accessible to quantum gas microscopes.

In particular, we study a one-dimensional Fermi-Hubbard system, and reveal effects of charge correlations on the spin correlations through Hamiltonian reconstruction. We next consider a model in mixed-dimensions, where holes are restricted to move in one dimension, but spin couplings are two-dimensional, and establish a quantitative understanding of the interplay of spin and charge through the introduction of frustrating diagonal bonds.

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Session Classification: Quantum Many-Body States