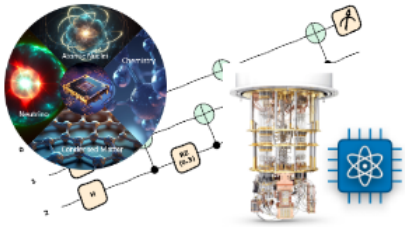

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Hybrid quantum-classical analog simulation of two-dimensional Fermi-Hubbard models with neutral atoms

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In this work, we implement a hybrid quantum-classical algorithm on a Rydberg-based analog quantum processor to simulate the two-dimensional Fermi-Hubbard model (FHM) which relies on a recent proposal. The latter exploits a Z_2 slave spin reformulation of the original interacting fermions in terms of self-correlated auxiliary spin degrees of freedom (naturally encoded in the Rydberg atom Quantum Processor Unit QPU), and noninteracting fermionic degrees of freedom (efficiently solvable classically).
To demonstrate the feasibility and utility of this approach, we experimentally realize the proposed hybrid quantum-classical algorithm to study the anisotropic Fermi-Hubbard model in the square lattice and its anisotropic version in the rectangular lattice with a qubit-based neutral-atom quantum processing unit. On the one hand, we study the Mott transition in an anisotropic Fermi-Hubbard model consisting of 36 electron sites at equilibrium. On the other hand, we also consider the nonequilibrium properties of the isotropic Fermi-Hubbard model in the square lattice after a sudden quench of the on-site interaction, for systems consisting of 36 and 64 electronic sites. We observe the expected collapsed oscillations of the quasiparticle weight in the Mott phase.

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