Mott physics with Rydberg atoms: using spin quantum simulators to simulate strong fermionic correlations

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In this work, we present a hybrid quantum classical strategy to solve a prototypical many-body fermionic problem, the Hubbard model, with an analog quantum processor with up to a few hundred Rydberg atoms [1]. We used an advanced self-consistent mapping between the fermionic problem and a spin model to circumvent the usual nonlocality issues related to fermion-to-spin transformations. We show that the method allows to compute key properties of the Hubbard model, like the quasiparticle weight renormalization, in the presence of realistic hardware constraints like decoherence, shot noise, readout error, atom position fluctuations. We focus our work on a single-orbital toy model at half-filling for this proof of concept. However, a crucial aspect of the method is that it is readily extendable to doped, and multiorbital problems, which are out of reach of other state-of-the-art classical methods.

[1] L. Henriet *et al.*, « Quantum computing with neutral atoms », *Quantum*, vol. 4, 2020.

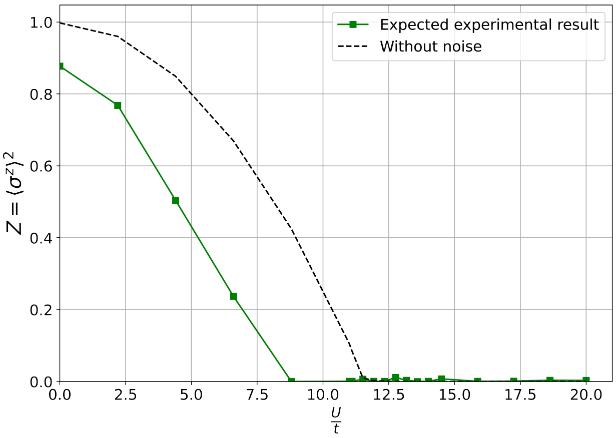

Figure 1: Quasiparticle weight renormalization vs. coulomb interaction renormalized. The black dashed line shows the result for a simulation without noise. The squared green line depicts the experimental result one can expect on a real device. The phase transition occurs when Z=0