Experimental realization of the cumulant expansion of the Lanczos Method for the calculation of Green's functions

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In this work, we present a quantum computational method to calculate the many-body Green's function matrix in a spin orbital basis. We apply our approach to finite-sized fermionic Hubbard models and related impurity models within Dynamical Mean Field Theory, and demonstrate the calculation of Green's functions on Quantinuum's H1-1 trapped-ion quantum computer. Our approach involves a cumulant expansion of the Lanczos method, using Hamiltonian moments as measurable expectation values. This bypasses the need for a large overhead in the number of measurements due to repeated applications of the variational quantum eigensolver (VQE), and instead measures the expectation value of the moments with one set of measurement circuits. From the measured moments, the tridiagonalised Hamiltonian matrix can be computed, which in turn yields the Green's function via continued fractions. While we use a variational algorithm to prepare the ground state in this work, we note that the modularity of our implementation allows for other (non-variational) approaches to be used for the ground state.

Figures

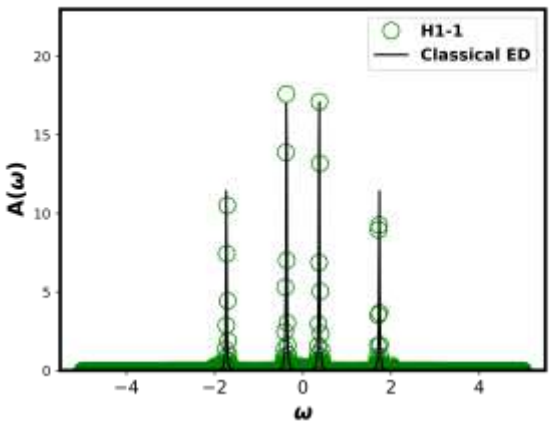

Figure 1: Spectral function for a Hubbard dimer obtained with the H1 Quantinuum ion trap device, compared with classical results