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Hybrid Digital/Analog Quantum Simulations via Optimal Control[1]

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Quantum computers hold the promise to open a new era in simulating quantum many-body systems. This era will bring us to a deeper and more complete understanding of dynamics and responses of strongly interacting systems, such as atomic nuclei, and their interactions with other forms of matter. However, current digital/universal quantum computers are too noisy to execute the formal algorithms that have been proposed to enact such simulations. Instead, hybrid digital-analog quantum computation, where the discrete quantum processor primitives are tailored to both the theoretical system being simulated and the physical quantum processor performing the simulations offers a path to useful predictions that can be realized within the near-term noisy intermediate-scale quantum (NISQ) era. Using optimal control to implement such a hybrid simulation, this approach is applied to compute the real-time evolution of the spin-dynamics of nucleons in classical numerical simulations of a quantum computer and for two nucleons performed on Lawrence Livermore National Laboratorys Quantum Design and Integration Testbed (QuDIT) platform. I will discuss our recent measurements on QuDIT and how we are extending this approach to larger systems and prospects for applying it on other quantum platforms.

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