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How tractable is the simulation of open quantum system dynamics of Ising models? ANUPAM MITRA, TAMEEM ALBASH, AKIMASA MIYAKE, IVAN DEUTSCH, University of New Mexico — A near-term goal for Noisy Intermediate Scale Quantum (NISQ) devices is quantum simulation of nonequilibrium dynamics in many-body systems [Preskill Quantum 2, 79 (2018)]. While the exact unitary dynamics of a closed many-body quantum systems is generally intractable, recent work has shown that approximate simulations of NISQ devices are tractable [Zhou, et al, arXiv:2002.07730; Noh, et al, arXiv:2003.13163]. We expect that classical simulation of certain quantum observables becomes tractable above a certain level of decoherence. We assume open quantum system dynamics given by a Lindblad master equation, which we solve using quantum trajectories and a matrix product state representation. We study this in the context of Ising spin chains in 1D, inspired by experiments using arrays of Rydberg atoms and trapped ions. We explore how decoherence allows for a larger truncation of the bond dimension of tensors in the matrix product state representation while still maintaining a good approximation to the exact dynamics. We find that for a fixed error budget, the complexity of the matrix product representation, is reduced for open quantum systems. This suggests that quantum simulation of many-body dynamics on NISQ devices may be classically tractable for some decoherence strengths.

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