Quench dynamics of lattice quantum many-body systems from time-dependent variational Monte Carlo

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The time-dependent variational principle allows one to investigate the dynamics of a lattice quantum many-body system, provided an Ansatz for its wave function (WF). Analogously to what is achievable by state-of-the-art quantum-simulator experiments, in a variational Monte Carlo simulation it is possible to initialize the system in a given state and follow its unitary dynamics after a quench of the hamiltonian parameters. In this framework, we focus on the paradigmatic transverse-field Ising model and on the pair-product, or Jastrow, variational state. We show that, despite its simplicity, the Jastrow WF i) does not suffer from a trivial "entanglement barrier" being capable of dealing with time evolutions featuring a volume law of entanglement growth and ii) is able, even in the extremely challenging one dimensional case, to capture fundamental dynamical aspects such as the light-cone like propagation of space-time correlations, and the essential features of the excitation spectrum, revealing, for example, quantum criticality. Refining the basic Jastrow WF in a physically motivated fashion by explicitly correlating different groups of sites in the Ansatz has the main effect of yielding a better description of the frequency of oscillations and time scales in the evolution of relevant quantities. This improvement is clearly detectable in non local (in space and time) observables such as the quench spectral function, which appears as a meaningful figure of merit for time dependent variational calculations. We finally show that, in two dimensions, the simple Jastrow variational Ansatz, without any modification, may lead to estimates in extremely good agreement with those obtainable via accurate alternative approaches or more sophisticated and computationally demanding WF's.