Out-of-equilibrium dynamics and thermalization of string order: from spin-1 chains to optical lattices

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Abstract:

Quantum phases of matter are characterized by the correlations of the underlying many-body wavefunction of the system. Although they are typically captured by a local order parameter, it has been shown that a broad class of systems, e.g. topologically ordered ones, possesses a non-local form order. I will begin by showing that such non-local order can be experimentally observed, as reported in some recent work on string order in 1D optical lattices [1, 2].

Afterwards, I will discuss the equilibration dynamics of string order in one-dimensional quantum systems. The problem is rather intriguing, as string order is a non-local quantity, and cannot be framed into the well-established picture of equilibration of local order parameters.

After initializing a spin-1 chain in the Haldane phase, the time evolution of non-local correlations following a sudden quench is studied by means of matrix-product-state-based algorithms. It is observed that thermalization occurs only for scales up to a horizon growing at a well defined speed, due to the finite maximal velocity at which string correlations can propagate, related to a Lieb-Robinson bound (which can also be formulated for string order).

The persistence of string ordering at finite times is non-trivially related to symmetries of the quenched Hamiltonian. A complete classification of when string order persists to a Hamiltonian global quench is given; the result is interestingly related to the concept of “symmetry protected topological order” [3].

A qualitatively similar behavior is found for the string order of the Mott insulating phase in the Bose-Hubbard chain. This paves the way towards an experimental testing of our results in present cold-atom setups.

Finally, it is discussed how to extend this work to the study of the out-of-equilibrium dynamics of topological order, addressing the dynamics of the entanglement spectrum in one-dimensional symmetry protected systems.

References:

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