Evolution after a quench of boundary driven open quantum systems

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Theoretical understanding on one hand and technological progresses on the other hand have made possible the experimental realization of early quantum mechanics models, as simple as one dimensional quantum spin chains, Fermi and Bose Hubbard models. The experimental advances made in manipulating and probing artificially assembled nano-objects made up of just a few atoms, one-dimensional structures, graphene plans, spin-chain materials, ultracold gases, have vivified the interest on their quantum dynamical behavior, which is often close to the ideal unitary evolution. A particularly important problem in this context is the non-equilibrium unitary evolution of a many-body quantum system after an interaction coupling has been varied more or less suddenly, the so-called quantum quench, and its apparent thermalisation toward a local (generalized)Gibbs states. In most of the cases discussed so far in the literature the non-equilibrium dynamics is started from an initial homogeneous equilibrium state and developed unitarily.

However, many situations of physical and technological interest have to deal with starting states that are inhomogeneous and intrinsically out of equilibrium, as for example situations where a macroscopic current is flowing through the system, where the presence of impurities can pin the elementary excitations and where the system interacts with an environment making the dynamics non-unitary. In such situations, at least in the weak coupling limit to the environment such open quantum system dynamics is precisely described through a Lindblad dynamical map [1]. Very recently, in the boundary driven homogeneous one-dimensional anisotropic Heisenberg spin 1/2 chain a very elegant solution for the non-equilibrium stationary state was obtained

[1] H.-P. Breuer, F. Petruccione, The Theory of Open Quantum Sys- tems, Oxford University Press, (2002).

in terms of a Matrix Product State involving matrices satisfying the quantum algebra $U_q[SU(2)]$ [2]. The purpose of this thesis is to study such out of equilibrium situations on one-dimensional boundary driven models like the Heisenberg chain with an initial inhomogeneous magnetization and/or initial finite current state. In particular, the focus will be on the possible generalization of Matrix Product States solutions to these kind of problems and its numerical implementation via an extension of the Density Matrix Renormalization Group to the non-unitary Lindblad maps.

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