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Quantum Dissipative Dynamics and their applications

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Abstract:

This thesis consists of various original approaches towards a better understanding of (local) dissipative dynamics. Such dynamics are described by completely positive operators. The thesis covers different aspects of this topic.

In the first part, we study such dynamics in the context of spin lattices. We then ask and answer questions such as how to understand the relations between information propagation and the mixing property of these dynamics. Both properties while being intrinsic of the dynamics are very difficult to unify. The former is a property independent of the size of system while the latter is mostly extensive. The main starting points are concepts of localization and rapid mixing. We propose constructions of different classes of generators inspired from such properties, which imply a new velocity of propagation of information which slows down in time.

In the second part, we try to understand detailed balance in the context of such large systems. The original motivation is to trivially connect quantum phases with classical nonequilibrium phases through the quasi-adiabatic evolution by mapping the generators of the classical stochastic dynamics onto local Hamiltonians. This leads us to a study and natural construction of invertible Matrix Product Operators.

In the third part, we focus on the natural emergence of completely positive operators in statistics through (discretized) quantum stochastic differential equations. It turns out that quantum dynamics are more natural operators even in the context of purely classical non-Markovian dynamics.

In the final part, we revisit the famous Kall ¨ en -Lehmann spectral representation of quantum ´ field theory through the study of parent Hamiltonians of injective Matrix Product States. In the long range and large system size limit, we can solve the low energy spectrum of these Hamiltonians. A natural representation of particles appears from the Fourier Transform of a quantum channel, i.e. the transfer matrix. In the same spirit as the the Kall ¨ en-Lehmann spectral ´ representation, we show that the spectrum of an interaction free dynamic is hidden inside the correlation of the ground state. As a side application, we use this insight to revisit Anderson’s localization in the picture of random matrix product states.