

Large coordination number expansion for quantum lattice systems

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The quantum lattice systems are encountered in many field of physics: solid states, ultra-cold gas and quantum meta-materials. The typical examples are the Bose or Fermi Hubbard models, or the Heisenberg spin model. An important application of these models is towards the investigation of essentially non-equilibrium and non-stationary effects such as quenching in a cold gas or evolution of a quantum annealer.

Our investigation is based on the general approach of $1/Z$ expansion (where Z is the lattice coordination number [1-4]). This formalism provides a general framework for building a hierarchy of equations for the reduced n -site density matrices, which allows a systematic approach to the calculation of the equilibrium properties [3, 4] as well as to describe its non equilibrium dynamics [1, 2]. In our latest work [4], we use the $1/Z$ expansion to determine the ground state and the quench dynamics of the quantum Ising model in one, two and three dimensions. Our method reproduces quite well the physics of this model such as the quantum phase transition between the paramagnetic and ferromagnetic phases or also the excitation spectrum. Such a model describes the dynamics of an array of quantum magnetic moments (e.g., qubits) perturbed by an external magnetic field under the conditions of long de-coherence time. Such structures containing over 2000 qubits are being currently produced for the use as quantum annealers, but despite intensive research the question of the degree of their "quantumness" and the character of their evolution remains open [5]. Our recent results [4] provide insight into the non-equilibrium correlations in these devices.

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[3] P. Navez et al., Phys. Rev. A **94**, 023629 (2016).

[4] P. Navez et al., Phys. Rev. B **95**, 064304 (2017).