Q 25: Quanteninformation: Konzepte und Methoden 3

Time: Tuesday 10:30–12:30 Location: V7.01

Q 25.1 Tue 10:30 V7.01

Exponential families of quantum states — •Sönke Niekamp[1], Tobias Galla[2], and Otfried Gühne[1] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Str. 3, D-57068 Siegen — [2]Complex Systems and Statistical Physics Group, School of Physics and Astronomy, University of Manchester, Manchester M13 9PL, United Kingdom

Exponential families provide a classification of multipartite quantum states according to their correlations. In this classification scheme, a state is considered as k-correlated if it can be written as thermal state of a Hamiltonian containing interactions between at most k parties. The distance of a state to an exponential family in terms of the relative entropy has been suggested as a correlation measure. The corresponding classical quantities have found application in the study of complex dynamical systems.

We present an efficient algorithm for the computation of the nearest k-correlated state (the information projection) of a given quantum state. In analogy to the task of entanglement detection, we consider witness operators which can be used to prove that an experimental state contains higher-order correlations. This is related to the question if certain relevant quantum states (such as cluster states) can be approximated by ground states of two-body Hamiltonians.

Q 25.2 Tue 10:45 V7.01

Constraints on measurement-based quantum computation in effective cluster states — Daniel Klagges and •Kai Phillip Schmidt — Lehrstuhl für Theoretische Physik I, TU Dortmund, Germany

The aim of this work is to study the physical properties of a one-way quantum computer in an effective low-energy cluster state. We calculate the optimal working conditions as a function of the temperature and of the system parameters. The central result of our work is that any effective cluster state implemented in a perturbative framework is fragile against special kinds of external perturbations. Qualitative aspects of our work are important for any implementation of effective low-energy models containing strong multi-site interactions.

Q 25.3 Tue 11:00 V7.01

Robustness of the two-dimensional cluster phase in an external magnetic field — •Henning Kalis, Daniel Klagges, and Kai Phillip Schmidt — Lehrstuhl für Theoretische Physik I, TU Dortmund, Germany

The cluster state represents a highly entangled state which is one central object for measurement-based quantum computing. Here we study the robustness of the cluster state on the two-dimensional square lattice at zero temperature in the presence of external magnetic fields by means of high-order series expansions. Interestingly, the phase diagram contains a self-dual line in parameter space allowing many precise statements about the fate of the cluster phase at finite fields. We provide strong evidences for first- and second-order phase transitions between the cluster phase and polarized phases.

Q 25.4 Tue 11:15 V7.01

Entanglement classes of three-qubit generalized Werner states — •Christopher Eltschka[1] and Jens Siewert[2,3] — [1]Institut für theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Departamento de Química Física, Universidad del País Vasco, 48080 Bilbao, Spain — [3]Ikerbasque, Basque Foundation for Science, 48011 Bilbao, Spain

Determining the entanglement properties of multipartite states is a notoriously hard problem. Even for mixed states of three qubits, no general solution is known. An important special case are the mixtures of a maximally entangled state with white noise, also known as generalized Werner states.

We provide a complete solution giving the entanglement class not only for the generalized Werner states based on the three-qubit GHZ state, but for all states sharing the same symmetry.

Q 25.5 Tue 11:30 V7.01

Quantifying tripartite entanglement for three-qubit generalized Werner states — •Jens Siewert[1,2] and Christopher Eltschka[3] — [1]Departamento de Química Física, Universidad del País Vasco , 48080 Bilbao, Spain — [2]Ikerbasque, Basque Foundation for Science, 48011 Bilbao, Spain — [3]Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany

The adequate quantification of entanglement in multipartite mixed states is still a theoretically unsolved problem, even in the case of three qubits. In order to investigate the robustness of entanglement against noise one often employs the so-called generalized Werner states, i.e., pure maximally entangled states mixed with the completely unpolarized state. Even for those states there are no quantitative results available.

In this contribution, we present the solution of the problem for three-qubit generalized Werner states (as well as for the whole family of full-rank mixed states which obey the Greenberger-Horne-Zeilinger symmetry) by providing an exact quantitative account of the tripartite entanglement contained in those states.

Q 25.6 Tue 11:45 V7.01

Measuring entanglement across a phase transition — •Oliver Marty, Marcus Cramer, and Martin Bodo Plenio — Institute für Theoretische Physik, Universität Ulm, Germany

In a recent experiment [1] an Ising model was simulated with trapped ions and different order parameters were measured across the paramagnetic-ferromagnetic phase transition. We show how entanglement may be quantified across this transition using already available simple measurements only, which are, in particular, exponentially more efficient than full state tomography. The suggested scheme holds the possibility to experimentally address questions of criticality and entanglement in a quantum many-body system.

[1] R. Islam et al., Nat. Commun. **2**, 377 (2011).

Q 25.7 Tue 12:00 V7.01

Perturbation Theory for Parent Hamiltonians of Matrix Product States — •Oleg Szehr and Michael Wolf — Technische Universität München, 85748 Garching, Germany

We consider generic Matrix Product States together with their canonical Parent Hamiltonians and analyze the stability of the spectral gap of such Hamiltonians under translation-invariant and local perturbations. Our results provide a perturbation theory for such Hamiltonians extending on the results by D. A. Yarotsky for the AKLT model.

Q 25.8 Tue 12:15 V7.01

Solving condensed matter ground state problems by semidefinite relaxations — •Thomas Barthel[1,2] and Robert Hübener[1,2] — [1]Freie Universität Berlin — [2]Universität Potsdam

We present a generic approach to the condensed matter ground state problem which is complementary to variational techniques and works directly in the thermodynamic limit. Relaxing the ground state problem, we obtain semidefinite programs (SDP). These can be solved efficiently, yielding lower bounds to the ground state energy and approximations to the few-particle Green's functions. As the method is applicable for all particle statistics, it represents in particular a novel route for the study of strongly correlated fermionic and frustrated spin systems in $D > 1$ spatial dimensions. It is demonstrated for the XXZ model and the Hubbard model of spinless fermions. The results are compared against exact solutions, Quantum Monte Carlo, and Anderson bounds, showing the competitiveness of the SDP method. Reference: arXiv:1106.4966.