Q 9: Quanteninformation: Konzepte II

Zeit: Montag 14:00–16:00 Raum: VMP 6 HS-D

Q 9.1 Mo 14:00 VMP 6 HS-D

Sequentially generated states for the study of two dimensional systems — •Mari-Carmen Banuls[1], David Perez-Garcia[2], Michael M. Wolf[3], Frank Verstraete[4], and J. Ignacio Cirac[1] — [1]Max-Planck-Institut fuer Quantenoptik, 85748 Garching, Germany — [2]Depto. Analisis Matematico, Universidad Complutense de Madrid, 28040 Madrid, Spain — [3]Niels Bohr Institut, 2100 Copenhagen , Denmark — [4]Fakultaet fuer Physik, Universitaet Wien, A-1090 Wien, Austria

The family of Matrix Product States represents a powerful tool for the study of physical one-dimensional quantum many-body systems, such as spin chains. Besides, Matrix Product States can be defined as the family of quantum states that can be sequentially generated in a one-dimensional system. We have introduced a new family of states which extends this sequential definition to two dimensions. Like in Matrix Product States, expectation values of few body observables can be efficiently evaluated and, for the case of translationally invariant systems, the correlation functions decay exponentially with the distance. We show that such states are a subclass of Projected Entangled Pair States and investigate their suitability for approximating the ground states of local Hamiltonians.

Q 9.2 Mo 14:15 VMP 6 HS-D

Random states with an energy constraint — •Markus Müller[1,2], Jens Eisert[1], and David Gross[3] — [1]Institut für Physik, Universität Potsdam, 14476 Potsdam — [2]Institut für Mathematik, TU Berlin, 10623 Berlin — [3]Institut für Mathematische Physik, TU Braunschweig, 38106 Braunschweig

We consider the question of how and whether thermal states emerge in parts of quantum systems if joint systems are in some random state of fixed energy. It is known that if one draws a random state according to the unitarily invariant measure in a composite system, then states of subsystems will with high probability be very close to being maximally mixed, if the environment is large enough. Here we consider the physically motivated question of looking at properties of random states under a meaningful energy constraint. To discuss this, we invoke techniques from concentration of measure and exploit a weak coupling limit, in an argument that is inspired by quantum information ideas. We outline ideas of how Gibbs states emerge in a weak coupling limit.

Q 9.3 Mo 14:30 VMP 6 HS-D

Real Space Renormalization Group Approach for Systems with Random Couplings. — •Oleg Gittsovich[1,2], Enrique Rico[3], and Hans J. Briegel[1,2] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Technikerstrasse 21a, A-6020 Innsbruck, Österreich — [2]Institut für Theoretische Physik, Universität Innsbruck, Technikerstrasse 25, A-6020 Innsbruck, Österreich — [3]Fakultät für Physik, Universität Wien, Boltzmanngasse 5, A-1090 Wien, Österreich

We present a real-space renormalization group (RG) approach for disordered systems. The Hamiltonian of the systems is defined on a rectangular two-dimensional lattice and has only nearest-neighbor interactions. The merits of presented method are twofold. On the one hand we preserve the symmetries of the system, i.e. at each step of the renormalization the system is self-similar. On the other hand the renormalization of the whole quantum system can be seen as a classical sequence of the renormalizations of the coarse-grained system. We provide several examples where the renormalization procedure leads to reliable results for random transverse field Ising model (RTFIM) on a two-dimensional rectangular lattice.

Q 9.4 Mo 14:45 VMP 6 HS-D

Pairing in fermionic systems: A quantum information perspective — •Christina Kraus[1], Michael Wolf[1,2], Ignacio Cirac[1], and Geza Giedke[1] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Niels-Bohr–Institut, Kopenhagen

The notion of "paired" fermions is central to important condensed matter phenomena such as superconductivity and superfluidity. While the concept is widely used and its physical meaning is clear there exists no systematic and mathematical theory of pairing which would allow to unambiguously characterize and systematically detect paired states. We propose a definition of pairing and develop methods for its detection and quantification applicable to current experimental setups. Pairing is shown to be a quantum correlation different from entanglement, giving further understanding in the structure of highly correlated quantum systems. In addition, we will show the resource character of paired states for precision metrology, proving that the BCS states allow phase measurements at the Heisenberg limit.

Q 9.5 Mo 15:00 VMP 6 HS-D

Adiabatic Preparation with Nonlinear Paths — •Gernot Schaller — Institut für Theoretische Physik, Technische Universität Berlin

Many interesting physical models show a quantum phase transition when a single parameter is varied through a critical point. For finite-size counterparts, there is usually a non-vanishing excitation gap at the critical point. This opens the possibility to adiabatically prepare the ground state of one phase from the ground state of another phase. When the parameter appears as a coupling constant (or as e.g. an external field) one may view this process as a straight line interpolation between two Hamiltonians. Unfortunately, the minimum excitation gap along this straight line trajectory often scales inversely with the system size. This does not only affect the adiabatic runtime but for systems coupled to a reservoir, also thermal excitations become likely.

For some simple models it will be demonstrated that with a nonlinear interpolation path a constant lower bound on the minimum energy gap can be proven. An interesting consequence is that the two-dimensional cluster state – encoded in the ground state of a Hamiltonian – can be prepared adiabatically in constant time.

[1] G. Schaller, Phys. Rev. A **78**, 032328 (2008).

Q 9.6 Mo 15:15 VMP 6 HS-D

Measuring mixed-state entanglement via antilinear operators — •Oliver Viehmann[1], Jens Siewert[1], Andreas Osterloh[2], and Armin Uhlmann[3] — [1]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg — [2]Institut für Theoretische Physik, Universität Hannover, 30167 Hannover — [3]Institut für Theoretische Physik, Universität Leipzig, 04109 Leipzig

The amount of entanglement in mixed quantum states is commonly defined via the convex-roof extension of a certain pure state entanglement measure, e.g., a polynomial invariant such as the concurrence [1]. For a pair of qubits, the convex roof of the pure-state concurrence can be obtained analytically [2].

The Wootters-Uhlmann method depends crucially on the properties of antilinear operators. In this contribution, we investigate a possible generalization of the Wootters-Uhlmann method for invariants which can be written as expectation values of antilinear operators with respect to multiple copies of a given pure state. In particular, we try to apply this method to invariants of polynomial degree 4 such as the three-way tangle.

[1] W. K. Wootters, Phys. Rev. Lett. **80**, 2245 (1998).
[2] A. Uhlmann, Phys. Rev. A **62**, 032307 (2000).

Q 9.7 Mo 15:30 VMP 6 HS-D

Entanglement Generation in Clifford Quantum Cellular Automata — •Johannes Gütschow[1], Zoltán Zimborás[2], and Reinhard Werner[1] — [1]Institut für Mathematische Physik, TU Braunschweig, www.imaph.tu-bs.de — [2]Theoretische Physik, Universität des Saarlands, www.uni-saarland.de/fak7/rieger

Clifford Quantum Cellular Automata (CQCA) are a special kind of Quantum Cellular Automata that incorporate Clifford group operations for the time evolution automorphism. Despite being classically simulable, they can be used as basic building blocks for universal quantum computation. This is due to the connection to translation-invariant stabilizer states and their entanglement properties. We investigate the generation of entanglement under CQCA action and show analytical and numerical results for the growth of entanglement for different classes of states and CQCA.

Q 9.8 Mo 15:45 VMP 6 HS-D

Factorization with Gauss Sums — •Sabine Wölk, Wolfgang Merkel, and Wolfgang Schleich — Institute of Quantum Physics, Ulm, Germany

Factoring large numbers N is one of the problems, for which analogue

computers need exponential time. Quantum computers on the other hand, can do this in polynomial time. In 1994 P. Shor introduced his famous quantum algorithm for this problem, but it is still difficult to realize it experimentally. As a consequence so far only the number $N = 15$ was factored with this algorithm.

For this reason we study the alternative route to factorization using Gauss sums. Our previous results have led to experimental factorizations of numbers N with up to 17 digits. However, our algorithm is slow because it checks every prime number $l < \sqrt{N}$ if it is a factor or not. Nevertheless there is still an enormous potential in Gauss sums for factoring numbers. In our talk we introduce some new ideainvolvingng entanglement.