Q 71: Quantum information: Concepts and methods VI

Time: Friday 16:30–18:30 Location: Kinosaal

Q 71.1 Fri 16:30 Kinosaal

Entanglement monogamy inspired variational ansatz for spin Hamiltonians — •Andreas Osterloh and Ralf Schützhold — Universität Duisburg-Essen, Duisburg, Germany.

Here we study the influence of the monogamy property of entanglement on the correlations in the ground state. We consider regular lattices of spins 1/2 (qubits) with coordination numbers Z, and derive rigorous bounds for the properties of the ground state, such as the ground state energy and the correlations between spins from the viewpoint of the monogamy of entanglement (and related inequalities). The limit that we are interested in is that of large Z, but also for general finite Z we give some results. These findings are relevant for obtaining good candidates for a variational ansatz for the ground state of these spin Hamiltonians (especially for large Z).

Q 71.2 Fri 16:45 Kinosaal

Propagation of Quantum Walks in Electric Fields — Christopher Cedzich[1], Tomas Rybar[1], •Albert H. Werner[2], Andrea Alberti[3], Maximilian Genske[3], and Reinhard F. Werner[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstrasse 2, 30167 Hannover, Germany — [2]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany — [3]Institut für Angewandte Physik, Universität Bonn, Wegelerstrasse 8, 53115 Bonn, Germany

We study one-dimensional quantum walks in a homogenous electric field. The field is given by a phase which depends linearly on position and is applied after each step. The long time propagation properties of this system, such as revivals, ballistic expansion, and Anderson localization, depend very sensitively on the value of the electric field, Φ, e.g., on whether $\Phi/(2\pi)$ is rational or irrational. We relate these properties to the continued fraction expansion of the field. When the field is given only with finite accuracy, the beginning of the expansion allows analogous conclusions about the behavior on finite time scales.

Q 71.3 Fri 17:00 Kinosaal

Adaptive mode transformations in fermionic tensor networks — •Christian Krumnow[1], Adam Nagy[1], Reinhold Schneider[2], Örs Legeza[3], and Jens Eisert[1] — [1]Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Berlin, Germany — [2]Institute for Mathematics, Technische Universität Berlin, Berlin, Germany — [3]Wigner Research Centre for Physics, Hungarian Academy of Sciences, Budapest, Hungary

Non-local fermionic models are frequently encountered in physics, most prominently in quantum chemistry, but also when capturing quantum lattice systems. The long-range nature of the interactions present in such systems, however, renders their straightforward numerical simulation using tensor-network methods difficult. When using a DMRG-based method, a suitable reordering of the orbitals will already reduce the computational effort. Still, one has more freedom to preprocess the Hamiltonian by means of suitable linear maps from one set of fermionic modes to another, aiming at minimising the entanglement present in the system. Here, we present an adaptive method that aims at combining advantages arising from suitable local mode transformations and matrix-product updates "on the fly" in an iterative fashion. First results – both for lattice models and for systems in quantum chemistry – suggest that by including such local mode transformations, one finds good approximations of the ground state already for low bond dimensions. In addition, we are able to recover suitable global mode transformations from the local ones for medium sized systems.

Q 71.4 Fri 17:15 Kinosaal

Novel condition for a quantum state to be Gaussian — Lucas Happ[1], •Maxim A. Efremov[1], Hyunchul Nha[2,3], and Wolfgang P. Schleich[1] — [1]Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQST), Universität Ulm, D-89081 Ulm, Germany — [2]School of Computational Sciences, Korea Institute for Advanced Study, Seoul 130-012, Korea — [3]Department of Physics, Texas A & M University at Qatar, PO Box 23874, Doha, Qatar

Gaussian states play a major role in quantum information with continuous variables. An important question for any practical implementation of such a state is to provide a user with a criterion or condition to verify that a given state is a Gaussian one. The obvious criterion for a pure state is the positivity of the corresponding Wigner function. However, this simple and fundamental criterion of Gaussianity is not easy to verify in practice.

For this reason, we introduce in this talk a new condition to distinguish a non-Gaussian state from a Gaussian one. Our considerations are based on the fact that any Gaussian state is fully characterized by the vector formed by the first moments and the covariance matrix. We examine the proposed condition, which relies on the sum of the all moments of the coordinate and momentum operators, for pure and mixed states.

Q 71.5 Fri 17:30 Kinosaal

Hybrid entanglement in the continuous variables of cylindrical vector beams — •Stefan Berg-Johansen[1,2], Christian Gabriel[1,2], Ioannes Rigas[1,2], Falk Töppel[1,2], Birgit Stiller[1,2], Tobias Röthlingshöfer[1,2], Andrea Aiello[1,2], Peter van Loock[1,2,3], Ulrik Andersen[1,2,4], Elisabeth Giacobino[5], Christoph Marquardt[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Guenther-Scharowsky-Str. 1/Bldg. 24, D-91058 Erlangen, Germany — [2]Institute of Optics, Information and Photonics, Univ. of Erlangen-Nuremberg, Staudtstr. 7/B2, D-91058 Erlangen, Germany — [3]Institute of Physics, Univ. of Mainz, Staudingerweg 7, 55128 Mainz, Germany — [4]Department of Physics, Technical Univ. of Denmark, 2800 Kongens Lyngby, Denmark — [5]Laboratoire Kastler Brossel, Univ. Pierre et Marie Curie, École Normale Supérieure, CNRS, 4 place Jussieu, 75252 Paris, France

Recently, it was shown that squeezed cylindrical vector beams exhibit hybrid entanglement between the polarization and transverse spatial degrees of freedom [1]. Here, hybrid entanglement arises naturally from an inseparability of the classical mode functions. We review the experimental techniques used to investigate this phenomenon [2], discuss an application to one-way quantum computing [3] and give an update on recent progress. A novel application of classical inseparability to optical measurements is presented.

[1] C. Gabriel et al., Phys. Rev. Lett. **106**, 060502 (2011)
[2] C. Gabriel et al., Eur. Phys. J. D **66**, 172 (2012)
[3] I. Rigas, C. Gabriel et al., arXiv:1210.5188 (2012)

Q 71.6 Fri 17:45 Kinosaal

Entanglement and observables for continuous-variable systems — •Kedar S. Ranade, Nico Grimmer, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, and Center for Integrated Quantum Science and Technology (IQ$^{\mathrm{ST}}$)

In finite-dimensional quantum systems it is known that the amount of entanglement in the system is fundamentally related to the set of accessible operations: any pure state can be interpreted to have any amount of entanglement, if this entanglement is defined with respect to an appropriate system of observables [1].

In this talk we present an extension to continuous-variable systems. Such systems can most conveniently be described in terms of their quasi-classical Wigner functions. The Wigner function is a representation of the density operator, and the transformations (such as the time evolution) correspond to symplectic maps. We analyse the behaviour of entanglement under such transformations for generic states.

[1] N. L. Harshman, K. S. Ranade, Phys. Rev. A **84** (2011), 012303

Q 71.7 Fri 18:00 Kinosaal

Approximate but Completely Positive Solutions of Lindblad Master Equations — •Farhang Haddad Farshi[1,2], Jian Cui[1,2], and Florian Mintert[1,2] — [1]FRIAS, Albert Ludwigs University of Freiburg, Albertstr. 19, 79104 Freiburg, Germany — [2]Department of Physics, Imperial College London, SW7 2AZ, United Kingdom

We consider approximate solutions of quantum mechanical Master equations with time-dependent generators. The Magnus expansion permits us to construct solutions that satisfy fundamental properties like semi-group and the conservation of trace; it does, however, not necessarily yield completely positive dynamics. We discuss how the Magnus expansion can be modified in order to also satisfy this property. With a few explicit examples we show that this modified expansion can yield a substantially improved approximation than the original one.

Q 71.8 Fri 18:15 Kinosaal

Matrix product states and variational methods applied to critical quantum field theory — •Ashley Milsted[1], Jutho Haegeman[2,3], and Tobias J. Osborne[1] — [1]Leibniz Universität Hannover, Institute of Theoretical Physics, Appelstrasse 2, D-30167 Hannover, Germany — [2]Vienna Center for Quantum Science and Technology, Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Wien, Austria — [3]Faculty of Physics and Astronomy, University of Ghent, Krijgslaan 281 S9, 9000 Gent, Belgium

The density matrix renormalization group (DMRG) has revolutionized the numerics of condensed matter systems in one dimension. Insight from quantum information explains its success in terms of the entanglement structure of low energy states, recognizing that DMRG ground states are matrix product states (MPS). We investigate whether such techniques are also advantageous when applied to a strongly coupled quantum field (ϕ^4 theory), where the usual method is quantum Monte Carlo (QMC). Using MPS in the thermodynamic limit (uMPS), we apply recently developed variational techniques, including a novel conjugate gradient solver, to obtain approximate ground states and low-lying excitations from which we extrapolate the ϕ^4 theory critical point in the continuum limit using only modest computational resources. Our estimate agrees well with QMC results, despite QMC being very different. We improve on a conflicting DMRG study by accounting for finite entanglement effects. The methods used are implemented as free software http://amilsted.github.io/evoMPS/.