Q 44: Quantum Information: Concepts and Methods III

Time: Thursday 10:30–12:30 Location: E 214

Q 44.1 Th 10:30 E 214

Maximally entangled states of polynomial $SL(2,\mathbb{C})$-invariant entanglement measures — •Andreas Osterloh[1] and Jens Siewert[2] — [1]FB Physik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany. — [2]Departamento de Química Física, Universidad del País Vasco - Euskal Herriko Unibertsitatea, Apdo. 644, 48080 Bilbao, Spain

Recently, a method for constructing $SL(2,\mathbb{C})$-invariant multipartite entanglement measures has been described for qubits by the authors [1]. These measures are particularly interesting since they are non-vanishing only for the non-zero SLOCC entanglement class as defined by Verstraete and coworkers [2]. Here, a detailed analysis is presented for those (maximally) entangled states states detected by thus-constructed polynomial SL-invariants. The analysis leads to the notion of (irreducibly) balanced states, which also proves to be tightly connected with an SLOCC classification of entanglement.

[1] A. Osterloh and J. Siewert, Phys. Rev. A **72**, 012337 (2005); –"– , Int. J. Quant. Inf. **4** 531 (2006).

[2] F. Verstraete, J. Dehaene, and B. D. Moor, Phys. Rev. A 68, 012103 (2003).

Q 44.2 Th 10:45 E 214

State reconstruction from few measurements — •Marcus Cramer[1] and Martin Plenio[2] — [1]Institute for Mathematical Sciences, Imperial College London, UK — [2]Institut für Theoretische Physik, Universität Ulm, Germany

Reconstructing a density matrix from measurement data is highly involved both from the experimental and the post-processing point of view: The number of measurements and computational resources needed to process them are exponentially large in the system size. If one knows that the system is in thermal equilibrium, one can do much better: We introduce a scheme that relies only on a linear number of correlation measurements. The computational resources needed to reconstruct the state with high fidelity from these measurements is only polynomial in the system size. The algorithm combines singular value thresholding and matrix product state methods.

Q 44.3 Th 11:00 E 214

Entanglement in quantum spin chains with broken reflection symmetry — •Zoltan Zimboras and Zoltan Kadar — Quantum Information Theory Group, ISI, Torino

Understanding the entanglement properties of systems with many degrees of freedom, such as quantum spin chains, has been one of the main recent research topics connecting quantum information theory and condensed matter physics. Huge amount of results has been accumulated about translation-invariant systems. However, the results almost exclusively correspond to systems having reflection symmetry, despite that models violating reflection invariance play a prominent role in many-body theory (e.g., in describing interactions of Dzyaloshinskii-Moriya type or non-equilibrium steady states). In this talk we will present some new results, both analytical and numerical, about the entanglement properties of non-reflection-invariant spin chains, and discuss how these differ from the reflection-invariant case (e.g., we dicuss the small "violation" of the Calabrese-Cardy formula for the finite size scaling of the entanglement entropy).

Q 44.4 Th 11:15 E 214

Quantifying entanglement from scattering data — •Harald Wunderlich[1,2,3], Marcus Cramer[1,2,3], and Martin B. Plenio[1,2,3] — [1]Institut für Theoretische Physik, Universität Ulm, Germany — [2]Institute for Mathematical Sciences, Imperial College London, United Kingdom — [3]QOLS, Blackett Laboratory, Imperial College London, United Kingdom

We demonstrate that the quantification of entanglement from scattering data according to an entanglement measure of choice (such as the robustness of entanglement or the best separable approximation) can be performed via a direct minimization of the entanglement over all states compatible with the measurement data. This can be achieved numerically employing methods from the theory of semidefinite programming.

Taking into account the symmetries allowed by the observables, the optimization may be restricted to states obeying the same symmetries. In order to illustrate the power of our method we apply this estimation method to thermal Heisenberg states.

Since for large quantum systems numerical calculations become intractable, we show how to obtain analytical lower bounds to entanglement measures via witness operators based on uncertainty relations.

Q 44.5 Th 11:30 E 214

Decoherence of spin gases induced by many-body phase gates — •Tatjana Carle[1], Wolfgang Dür[1,2], Hans J. Briegel[1,2], and Barbara Kraus[1] — [1]Institut für Theoretische Physik, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck — [2]Institut für Quantenoptik und Quanteninformation der Österreichischen Akademie der Wissenschaften, Technikerstraße 21a, A-6020 Innsbruck

We present a new approach to study the properties of many-particle systems subject to decoherence. In particular, we consider a spin gas, which is a natural extension of a classical gas where the particles move along a classical trajectory, but carry a quantum degree of freedom, which interacts during collisions. Formerly, two-body collisions between the system and bath, which were described by two-body phase gates leading to a dephasing environment, were considered. There the evolution of the system and the entanglement has been investigated. Here we consider a system of particles (qubits) which is interacting via more-body phase gates with its surrounding. We study the entanglement properties of the multipartite system depending on the number of qubits the phase gate is acting on. We calculate the reduced density matrix and decoherence maps which gives us insight into the entanglement properties and time evolution of the system. In order to do so we make use of a new class of quantum states called LME states (Locally-Maximally-Entanglable), which are generated by n-body phase gates. Since the calculations are exact we treat Markovian as well as Non-Markovian scenarios and compare them to each other.

Q 44.6 Th 11:45 E 214

Controlled Antiadiabatic Crossing of Quantum Phase Transitions — Patrick Doria, Tommaso Calarco, and •Simone Montangero — Ulm University, Ulm, Germany

A control strategy that can be applied to a vast range of non integrable one dimensional systems is introduced and applied to the 1D Mott Insulator-Superfluid quantum phase transition recently demonstrated in cold atoms in optical lattice experiments. We present an optimal pulse to speed up of about an order of magnitude the experimental setup of T.Stoeferle, et. al., Phys. Rev. Lett. 92, 130403 (2004).

Q 44.7 Th 12:00 E 214

Entanglement Transmission under Adversarially Selected Quantum Noise — Rudolf Ahlswede[2], Holger Boche[1], Igor Bjelakovic[1], and •Janis Nötzel[1] — [1]Technische Universität Berlin, Lehrstuhl für Informationstheorie und theoretische Informationstechnik — [2]Universität Bielefeld, Arbeitsgruppe Information und Komplexität

We consider the problem of entanglement transmission over arbitrarily varying quantum channels (AVQC's) and prove a quantum version of the famous Ahlswede dichotomy.

To start with, we use the existence of entanglement transmission codes for compound quantum channels to obtain common-randomness-assisted entanglement transmission codes for AVQC's.

As a second step, we show that we actually only need very small amounts of common randomness, leading to the proposed quantum version of Ahlswede's dichotomy through derandomization by classical forward-communication.

As a last point, we present a first attempt to derive a necessary and sufficient condition for the capacity of the AVQC to be equal to zero.

Q 44.8 Th 12:15 E 214

Increasing the statistical significance of entanglement detection in experiments — •Bastian Jungnitsch[1], Sönke Niekamp[1], Matthias Kleinmann[1], Otfried Gühne[1], He Lu[2], Wei-Bo Gao[2], Yu-Ao Chen[2,3], Zeng-Bing Chen[2], and Jian-Wei Pan[2,3] — [1]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria — [2]Hefei National Laboratory for Physical Sciences at Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China — [3]Physikalisches Institut, Universität Heidelberg, Heidelberg, Germany

Entanglement is often verified by a violation of an inequality like a Bell inequality or an entanglement witness. Considerable effort has been devoted to the optimization of such inequalities in order to obtain a high violation.

We demonstrate theoretically and experimentally that such an optimization does not necessarily lead to a better entanglement test, if the statistical error is taken into account. Theoretically, we show for different error models that reducing the violation of an inequality can improve the significance. We show this to be the case for an error model in which the variance of an observable is interpreted as its error and for the standard error model in photonic experiments. Specifically, we demonstrate that the Mermin inequality yields a Bell test which is statistically more significant than the Ardehali inequality in the case of a photonic four-qubit state that is close to a GHZ state.

Experimentally, we observe this phenomenon in a four-photon experiment, testing the above inequalities for different levels of noise.