Q 50: Quantum information: Concepts and methods III

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

Q 50.1 Thu 16:30 Kinosaal

Designing Bell Inequalities from a Tsirelson Bound — •Michael Epping, Hermann Kampermann, and Dagmar Bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Universitätsstr. 1, D-40225 Düsseldorf

In analogy to the local hidden variable bounds of Bell inequalities, Tsirelson bounds restrict their value predicted by quantum theory. We derive simple Tsirelson bounds for general CHSH type inequalities based on the maximal singular value of the matrix of coefficients, analyze its tightness and give several applications. In particular our method allows to optimize Bell inequalities by applying operations that do not affect the Tsirelson bound and the optimal observables.

Q 50.2 Thu 16:45 Kinosaal

Lieb-Robinson Bounds for Spin-Boson Lattice Models and Trapped Ions — •Johannes Jünemann[1,2,3], Andrea Cadarso[2,4], David Pérez-García[4], Alejandro Bermudez[2], and Juan-José García-Ripoll[2] — [1]Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55099 Mainz, Germany — [2]Instituto de Física Fundamental IFF-CSIC, Calle Serrano 113b, Madrid E-28006, Spain — [3]Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [4]Facultad de Matemáticas, Universidad Complutense de Madrid, Avenida Complutense s/n, Madrid E-28040, Spain

We derive a Lieb-Robinson bound for the propagation of spin correlations in a model of spins interacting through a bosonic lattice field, which satisfies a Lieb-Robinson bound in the absence of spin-boson couplings. We apply these bounds to a system of trapped ions and find that the propagation of spin correlations, as mediated by the phonons of the ion crystal, can be faster than the regimes currently explored in experiments. We propose a scheme to test the bounds by measuring retarded correlation functions via the crystal fluorescence.

[1] Phys. Rev. Lett. 111, 230404 (2013)

Q 50.3 Thu 17:00 Kinosaal

The Cauchy-Schwarz inequality: a powerful tool to detect entanglement — •Sabine Wölk and Otfried Gühne — Department Physik, Universität Siegen, 57068 Siegen, Germany

Entanglement is an important resource for quantum cryptography, quantum computing and quantum metrology. So far, no entanglement criteria exist, which are necessary and sufficient for all states. Therefore, many different criteria coexist. Some of them are in the form of inequalities of expectation values. These criteria are especially useful for experimental application. In this talk, we show how to derive such entanglement criteria by using two non-hermitian operators per subsystems and the help of the Cauchy-Schwarz inequality. In this way, new criteria and already existing criteria can be proven. In the bipartited case the collectivity of criteria derived with Cauchy-Schwarz are closely connected to the PPT-criterion. However, our criteria do not require a complete state tomography, a few measurement direction are sufficient. Furthermore, in the multipartite case, our criteria can also detect entangled states, which are biseparable under every bipartition and can therefore not be detected by the PPT-criterion.

Q 50.4 Thu 17:15 Kinosaal

Generalized squeezing inequalities, entanglement and its depth — Giuseppe Vitagliano[1], Zoltan Zimboras[1], and •Geza Toth[1,2,3] — [1]Department of Theoretical Physics, University of the Basque Country UPV/EHU, P.O. Box 644, E-48080 Bilbao, Spain — [2]IKERBASQUE, Basque Foundation for Science, E-48011 Bilbao, Spain — [3]Wigner Research Centre for Physics, Hungarian Academy of Sciences, P.O. Box 49, H-1525 Budapest, Hungary

We present a general method to derive sets of $SU(d)$ squeezing inequalities for d-level particle systems. In [1] we presented a set of necessary separability criteria based on the first and the "modified" second moments of collective operators. Considering the total spin components as collective operators, these conditions yield the so-called generalized spin squeezing inequalities [2], which outperform traditional methods for detecting entanglement in spin ensembles (like the criterion of Ref. [3]). Here we present similar entanglement conditions based on the first and modified second moments of the collective $SU(d)$-generators. From these we define a parameter that is suitable to detect entangled states that might be useful for quantum metrology and even states that are biseparable with respect to all possible bipartitions. We also present a criterion for detecting the entanglement depth, i.e., whether the state is k-producible or not.

[1] GV, P. Hyllus, I.L. Egusquiza, and G. Tóth, PRL **107**, 240502
[2] GV, I. Apellaniz, I.L. Egusquiza, and G. Tóth, arXiv:1310.2269
[3] A. Sørensen, L.-M. Duan, J.I. Cirac, P. Zoller, Nature **409**, 63 (2001).

Q 50.5 Thu 17:30 Kinosaal

Bell Inequality violations in entangled K-meson pairs — •Marius Paraschiv, Otfried Guehne, and Thomas Mannel — Universität Siegen, Department Physik, Emmy-Noether-Campus , Walter-Flex-Straße 3 , 57068 Siegen , Germany

The quantum mechanical violation of Bell inequalities has been thoroughly verified during the last thirty years through various ion and photon experiments. In this contribution I will present our work on the study of Bell inequality violations for pairs of entangled neutral K mesons. The important difference from the usual ion / photon cases is that K mesons decay, therefore all decay products must be included. By considering both strangeness and the combined CP operation, an analogy can be made with other, well known, two-level systems. Bell inequalities are treated both in terms of quasi spin measurements and different time measurements. A special type of inequality besides the standard CHSH inequality is the Sliwa-Collins-Gisin inequality. Besides being another example of Bell test, the investigation of entanglement in particle physics may have applications for entanglement-enhanced measurements.

Q 50.6 Thu 17:45 Kinosaal

Entropic inequalities in non-locality and causal discovery — Rafael Chaves, •Lukas Luft, and David Gross — University of Freiburg, Germany

The fields of quantum non-locality in physics, and causal discovery in machine learning, both face the problem of deciding whether observed data is compatible with a presumed causal relationship between the variables (for example a local hidden variable model).

Traditionally, in the field of non-locality, Bell inequalities have been used to describe the restrictions imposed by causal structures on marginal distributions. However, some such structures give rise to non-convex constraints on the accessible data, and it has recently been noted that linear inequalities on the observable entropies capture these situations more naturally. In this way, one can go beyond the usual Bell setup, exhibiting inequalities for scenarios with extra conditional independence assumptions, as well as a limited amount of shared randomness between the parties.

The entropic approach can also be applied to classical causal inference. The original discovery algorithms only consider the absence or presence of correlations in empirical data, but not their strength. We present instances of classical causal models that can be distinguished entropically, but not based on observed independences.

Q 50.7 Thu 18:00 Kinosaal

Area law violation for the mutual information in a nonequilibrium steady state — Viktor Eisler[1] and •Zoltán Zimborás[2] — [1]Eötvös University, Budapest, Hungary — [2]University of the Basque Country UPV/EHU, Bilbao, Spain

We study the nonequilibrium steady state of an infinite chain of free fermions, resulting from an initial state where the two sides of the system are prepared at different temperatures. The mutual information is calculated between two adjacent segments of the chain and is found to scale logarithmically in the subsystem size. This provides the first example of the violation of the area law in a quantum many-body system outside a zero temperature regime. The prefactor of the logarithm is obtained analytically and, furthermore, the same prefactor is shown to govern the logarithmic increase of mutual information in time, before the system relaxes locally to the steady state.

V. Eisler and Z. Zimborás, arXiv:1311.3327

Q 50.8 Thu 18:15 Kinosaal

Correlations and Area Laws in Open quantum Systems — •Michael Kastoryano and Jens Eisert — Freie Universität Berlin, Germany

Understanding the dynamic and static properties of correlated quantum systems on a lattice remains one of the important goals of condensed matter physics. We present here a deep connection between the relaxation behavior of Markovian open system dynamics and the correlation properties of the stationary state of the system, using methods from quantum information theory. As a consequence, we identify a regime where an Area Law can be shown to hold for all dimensions, and where the dynamics are stable to small perturbations. We conclude with a discussion of the implications of these results for the classical simulation of open quantum systems with matrix-product operators and the robust dissipative preparation of topologically ordered states of lattice spin systems.