Q 11: Quantum Information (Concepts and Methods) I

Time: Monday 14:00–15:45 Location: S HS 001 Chemie

Q 11.1 Mon 14:00 S HS 001 Chemie

Characterizing the structure of temporal quantum correlations — •Yuanyuan Mao, Cornelia Spee, Zhen-Peng Xu, and Otfried Gühne — Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany

Subjecting a single system to a sequence of measurements of certain length, with the possible measurements selected from a given set, one obtains a probability distribution which encodes temporal correlations. These correlations can be used for example to illustrate the distinction between quantum and classical theories through Leggett-Garg or Kochen-Specker inequalities. In this work, we investigate the structure of the set of temporal correlations generated by quantum systems of fixed dimension. For given scenarios, firstly we show that the sets of correlations are generally non-convex for small-dimensional systems. We then give the minimal dimensions needed to obtain a convex set of correlations and derive several nonlinear inequalities to detect the non-convexity for systems with smaller dimensions.

Q 11.2 Mon 14:15 S HS 001 Chemie

Distribution of N-party correlations — •Christopher Eltschka[1] and Jens Siewert[2,3] — [1]Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany — [2]University of the Basque Country UPV/EHU, E-48080 Bilbao, Spain — [3]IKERBASQUE Basque Foundation for Science, E-48013 Bilbao, Spain

One of the peculiar features of quantum mechanics is that a generic pure multipartite state is not completely described by the states of its subsystems.

The Bloch representation, that is an expansion of the state in terms of a local matrix basis, allows for a clean separation of multipartite features based on the number of parties involved.

When doing that separation, a natural question is how much "weight" the state has in its k-partite features (the "k-sector") [1,2], or more precisely, what is the total Hilbert-Schmidt length of all terms that act nontrivially on exactly k parties.

A particularly interesting question is how this "sector distribution" correlates with the entanglement features of the state. It turns out that entanglement properties in general do not depend on a single sector (such as, e.g., the N-body sector), but on the entire sector distribution.

We present results regarding the sector distribution demonstrating that its relation to entanglement is not always what one might intuitively expect.

[1] Tran, Daki, Laskowski, Paterek, Phys. Rev. A **94**, 042302 (2016)
[2] Huber, Gühne, Siewert, Phys. Rev. Lett. **118**, 200502 (2017)

Q 11.3 Mon 14:30 S HS 001 Chemie

Stochastic Coherence Theory for Qubits — •Thomas Theurer[1], Alexander Streltsov[2,3], and Martin Bodo Plenio[1] — [1]Institute of Theoretical Physics, Universität Ulm, Albert-Einstein-Allee 11, D-89069 Ulm, Germany — [2]Faculty of Applied Physics and Mathematics, Gdańsk University of Technology, 80-233 Gdańsk, Poland — [3]National Quantum Information Centre in Gdańsk, 81-824 Sopot, Poland

The resource theory of coherence studies the operational value of superpositions in quantum technologies. A key question in this theory concerns the efficiency of manipulation and interconversion of this resource. Here we solve this question completely for mixed states of qubits by determining the optimal probabilities for mixed state conversions via stochastic incoherent operations. This implies new lower bounds on the asymptotic state conversion rate between mixed single-qubit states which in some cases are proven to be tight. The results on qubits are partially generalized to arbitrary dimensions and assisted state transformations are considered. Furthermore, we obtain the minimal distillable coherence for given coherence cost among all single-qubit states, which sheds new light on the irreversibility of coherence theory.

Q 11.4 Mon 14:45 S HS 001 Chemie

Detecting Coherence via Spectrum Estimation — •Xiao-Dong Yu and Otfried Gühne — University of Siegen, 57068 Siegen, Germany

Quantum coherence is a fundamental feature of quantum mechanics, describing the capability of a quantum state to exhibit quantum interference phenomena. Consequently, it is an essential ingredient in quantum information processing, and plays a central role in emergent fields, such as quantum metrology and quantum thermodynamics.

In recent years, the quantification of coherence has attracted a lot of interest, but the lack of efficient methods to measure the coherence in experiments limits the applications. In this work, we address this problem by introducing an experiment-friendly method for coherence and spectrum estimation. This method is based on the theory of majorization and can not only be used to prove the presence of coherence, but also result in a rather precise lower bound of the amount of coherence. As an illustration, we show how to characterize the freezing phenomenon of coherence with only two local measurements for any N-qubit quantum systems.

As the majorization theory is also widely-used in physics, statistics, and economics, our approach may also have many other applications. As examples, we show that our method can be used for the characterization of distillability and entanglement transformations.

Q 11.5 Mon 15:00 S HS 001 Chemie

Quantum coherence in composite systems — •Jan Sperling[1], Elizabeth Agudelo[2], and Armando Perez-Leija[3] — [1]Applied Physics, University of Paderborn, Warburger Str. 100, 33098 Paderborn, Germany — [2]QSTAR, INO-CNR and LENS, Largo Enrico Fermi 2, I-50125 Firenze, Italy — [3]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany

Quantum correlations between different systems play a crucial role for implementing quantum information technologies. In this contribution, we discuss a general framework for studying quantum phenomena in composite systems. In particular, we focus on correlations that are incompatible with classical models, enabling the verification of quantum effects. Our studies include the certification of quantum coherence between indistinguishable particles and in hybrid systems, consisting of a discrete-variable and a continuous-variable subsystem. Moreover, the fundamental notion of quantum entanglement is analyzed along with and compared to other forms of quantum correlations in multipartite systems. While mainly focusing on theoretical advances, we also report on recent experimental implementations.

Q 11.6 Mon 15:15 S HS 001 Chemie

Quantifying quantum resources with conic programming — •Tristan Kraft[1], Roope Uola[1], Jiangwei Shang[2], Xiao-Dong Yu[1], and Otfried Gühne[1] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Str. 3, D-57068 Siegen, Germany — [2]Beijing Key Laboratory of Nanophotonics and Ultrafine Optoelectronic Systems, School of Physics, Beijing Institute of Technology, Beijing 100081, China

Quantum resource theories have attracted much interest recently. Their aim is to formalise the quantification and manipulation of quantum resources, which include but are not limited to entanglement, asymmetry and coherence of quantum states, or incompatibility of quantum measurements. Given a quantum resource, one can ask whether it is useful for some task, specifically if there is a task in which it performs better than any resourceless state or measurement.

Using the techniques from conic programming, we prove that in any resource theory (with a convex and compact set of free resources) associated to quantum state assemblages or quantum measurements, the resource can be seen as the ability to outperform the free states in some minimum-error state discrimination task. Moreover, we show that this outperformance can be quantified by an appropriate robustness measure. We apply the technique to various explicit sets of free states, e.g. joint measurability, POVMs simulable by projective measurements, and state assemblages preparable with a given Schmidt number.

Q 11.7 Mon 15:30 S HS 001 Chemie

Non-asymptotic assisted distillation of quantum coherence — Bartosz Regula[1], Ludovico Lami[1], and •Alexander Streltsov[2,3] — [1]University of Nottingham, United Kingdom — [2]Centre of New Technologies, University of Warsaw, Poland — [3]Gdansk University of Technology, Poland

We characterize the operational task of environment-assisted distillation of quantum coherence under different sets of free operations when only a finite supply of copies of a given state is available. We first evaluate the one-shot assisted distillable coherence exactly, and introduce a semidefinite programming bound on it in terms of a smooth entropic quantity. We prove the bound to be tight for all systems in dimensions 2 and 3, which allows us to obtain computable expressions for the one-shot rate of distillation, establish an analytical expression for the best achievable fidelity of assisted distillation for any finite number of copies, and fully solve the problem of asymptotic zero-error assisted distillation for qubit and qutrit systems. Our characterization shows that all relevant sets of free operations in the resource theory of coherence have exactly the same power in the task of one-shot assisted coherence distillation, and furthermore resolves a conjecture regarding the additivity of coherence of assistance in dimension 3.