Q 56: Quantum Information (Coherence and Entanglement)

Time: Thursday 10:30–12:30 Location: K 1.019

Q 56.1 Thu 10:30 K 1.019

Structure of the resource theory of quantum coherence — •Alexander Streltsov[1], Swapan Rana[2], Paul Boes[3], and Jens Eisert[3] — [1]Gdansk University of Technology, Poland — [2]ICFO, Barcelona, Spain — [3]Freie Universität Berlin, Germany

Quantum coherence is an essential feature of quantum mechanics which is responsible for the departure between classical and quantum world. The recently established resource theory of quantum coherence studies possible quantum technological applications of quantum coherence, and limitations which arise if one is lacking the ability to establish superpositions. An important open problem in this context is a simple characterization for incoherent operations, constituted by all possible transformations allowed within the resource theory of coherence. Here, we contribute to such a characterization by proving several upper bounds on the maximum number of incoherent Kraus operators in a general incoherent operation. For a single qubit, we show that the number of incoherent Kraus operators is not more than 5, and it remains an open question if this number can be reduced to 4. The presented results are also relevant for quantum thermodynamics, as we demonstrate by introducing the class of Gibbs-preserving strictly incoherent operations, and solving the corresponding mixed-state conversion problem for a single qubit.
See also A. Streltsov, S. Rana, P. Boes, and J. Eisert,
Phys. Rev. Lett. **119**, 140402 (2017).

Q 56.2 Thu 10:45 K 1.019

Coherence Fluctuation Relations — •Benjamin Morris, Bartosz Regula, and Gerardo Adesso — School of Mathematical Sciences, University of Nottingham, University Park, Nottingham NG7 2RD, United Kingdom.

Following recent work on the role of resource theories in the emergence of fluctuation relations, we have identified coherence fluctuation theorems during a pure state transformation. These results have allowed a formal identification of relations analogues to the Jarzynski and Crooks relations within the resource theory of quantum coherence. This has been achieved by considering reversible pure state manipulations under strictly incoherent operations supplemented by the use of a coherence battery, i.e., a storage device whose degree of coherence is allowed to fluctuate while mediating the transformation. The necessity of a battery to mediate the transformation allows a comparison of coherent transformations to classical thermodynamic transformations where the amount of fluctuating work is generally described via an intermediary system. Our work on coherence provides another example of a resource theory (in addition to athermality and entanglement) where a connection is established between majorization theory and fluctuation relations. This is hoped to provide further insight into the general structure of battery assisted quantum resource theories, and more specifically in the interplay between quantum coherence and quantum thermodynamics.

Q 56.3 Thu 11:00 K 1.019

A resource theory of quantum process coherence — •Felix Bischof, Hermann Kampermann, and Dagmar Bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany

The coherent superposition of states is one of the fundamental features of quantum mechanics that distinguish it from the classical realm. In particular, virtually any quantum information protocol requires coherence in order to achieve a quantum advantage. Recently, coherence has received renewed attention in the context of a resource theory [1], in which coherence is a valuable resource that, due to restrictions on operations, can only be processed but not generated. In this context, coherence-free states, coherence-nonincreasing operations, and coherence measures are defined with respect to a fixed quantum state basis. We investigate a generalization of the concept of coherence with respect to general quantum processes. In particular, we argue how the ingredients of a generalized resource theory of coherence can be obtained.

[1] A. Streltsov, G. Adesso, and M. B. Plenio, Rev. Mod. Phys. 89, 041003 (2017)

Q 56.4 Thu 11:15 K 1.019

Distribution of coherence in multipartite systems — •Tristan Kraft and Marco Piani — University of Strathclyde, Glasgow G4 0NG, United Kingdom

We study the distribution of quantum coherence in multipartite systems, by comparing the global coherence to the coherence of the marginals. First we introduce a quantifier in terms of the relative entropy of coherence to measure how much the global state is coherent compared to its marginals. We evaluate this quantifier for maximally entangled two-qubit states. Interestingly, we find that there are coherent states that are locally incoherent, but the coherence can be completely transferred to its marginals by decorrelating the system using incoherent unitary operations. States for which this is impossible are genuinely multipartite coherent. We provide necessary and sufficient conditions for pure states to have zero genuine multipartite coherence. Furthermore, we calculate the amount of genuine multipartite coherence for two-qubit pure states.

Q 56.5 Thu 11:30 K 1.019

Subcycle tracing of ultrabroadband squeezed light transients from nonlinear crystals — •Matthias Kizmann[1], Thiago Lucena de M. Guedes[1], Philipp Sulzer[1], Denis V. Seletskiy[2], Andrey S. Moskalenko[1], Alfred Leitenstorfer[1], and Guido Burkard[1] — [1]Department of Physics and Center for Applied Photonics, University of Konstanz, Germany — [2]Department of Engineering Physics, Polytechnique Montréal, C-6079 Montréal, Canada

The electro-optic effect can be used to sample the vacuum fluctuations of the electric field [1]. Moreover, this technique provides a way to study the dynamics of the variance of the probed field with subcycle resolution. Recently, this was shown by sampling the relative differential noise patterns of a transient squeezed vacuum state generated in a thin nonlinear crystal [2]. We demonstrate theoretically that the quantum dynamics of ultrabroadband squeezed light transients generated in thin nonlinear crystals can be determined for certain characteristic shapes of the driving few-cycle coherent pulses. The squeezing and anti-squeezing can be interpreted as a result of a change in the local run of time, induced by the driving pulse. Furthermore, we predict that the conventionally observed asymmetry between squeezing and more pronounced anti-squeezing in the temporal noise traces, resulting from the product character of Heisenberg's uncertainty relation, can be reversed with specific driving pulses. We argue that this phenomenon can be realized under realistic conditions of the state-of-art experiments.

[1] C. Riek et al., Science 350, 420 (2015).
[2] C. Riek et al., Nature 541, 376 (2017).

Q 56.6 Thu 11:45 K 1.019

Characterizing Multipartite Entanglement — •Jan Sperling and Ian Walmsley — Clarendon Laboratory, University of Oxford, United Kingdom

Quantum correlations between multiple degrees of freedom or particles play a fundamental role for quantum communication protocols. In this contribution, we describe how complex structures of multipartite entanglement can be certified using nonlinear eigenvalue equations [1]. This allows for the in-depth analysis of entanglement between many parties and the formulation of measurable entanglement criteria. Recent experimental applications to frequency combs underline the capabilities of our method [2]. Finally, the entangling dynamics of interacting systems is uncovered by nonlinear Schroedinger-type equations [3]. Consequently, we present a unified framework to study quantum entanglement in stationary and time-dependent, multipartite systems.

[1] J. Sperling and W. Vogel, Phys. Rev. Lett. 111, 110503 (2013). [2] S. Gerke, J. Sperling, W. Vogel, Y. Cai, J. Roslund, N. Treps, and C. Fabre, Phys. Rev. Lett. 114, 050501 (2015). [3] J. Sperling and I. A. Walmsley, Phys. Rev. Lett. 119, 170401 (2017).

Q 56.7 Thu 12:00 K 1.019

Characterizing entanglement with scrambled data — •Timo Simnacher[1], Nikolai Wyderka[1], Gael Sentís[1], Rene Schwonnek[2], and Otfried Gühne[1] — [1]Universität Siegen, Siegen, Germany — [2]Leibniz Universität Hannover, Hannover, Germany

In an ordinary entanglement detection scenario, the possible measurements and the corresponding data are given. In contrast to device-independent scenarios, where the measurements are not characterized but the data have a clear interpretation, we consider the case where the measurements are characterized but the data is scrambled. That means, the assignment of outcomes to the corresponding probabilities is unknown.

As an example, we investigate the two-qubit scenario with local measurements of $\sigma_x \otimes \sigma_x$ and $\sigma_z \otimes \sigma_z$. In this setting, we first find a class of entanglement witnesses invariant under permutation of probabilities and hence, it is indeed possible to detect entanglement even when the data is scrambled. Second, since entropies are naturally invariant under scrambling, it seems reasonable to consider entropic uncertainty relations to detect entanglement. Numerical and analytic results indicate that Shannon entropy is not suitable in this scenario, however, using Tsallis entropy $H_q(p_i) = \frac{1}{q-1}(1-\sum_i p_i^q)$ is a promising approach for some q.

Q 56.8 Thu 12:15 K 1.019

Unitary designs for reference-frame independent entanglement detection — •Andreas Ketterer, Nikolai Wyderka, and Otfried Gühne — Universität Siegen, Siegen, Germany

The trustworthy detection of multipartite entanglement usually requires a number judiciously chosen local quantum measurements which are aligned with respect to a previously shared common reference frame. If such a reference frame is not available one has to develop alternative detection strategies which do not rely on a specific choice of the local measurement bases. One possibility in this direction is to perform a number of local measurements with settings distributed uniformly at random. Using such a statistical treatment we show that one can make use of quantum unitary designs to derive reference frame independent multi-qubit entanglement criteria based on the first six moments of the randomly measured expectation values. We illustrate our method in the case of a bipartite system where it allows for a characterization of all entangled Bell diagonal states. Subsequently, we move to the more involved multipartite scenario and show how to detect multi-qubit entanglement from two-body correlations.