Q 50: Quantum Information: Concepts and Methods VII

Time: Thursday 11:00–13:00 Location: K/HS1

Q 50.1 Thu 11:00 K/HS1

Weak thermal contact is not universal for work extraction — •Henrik Wilming, Rodrigo Gallego, and Jens Eisert — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany

The free energy difference to the equilibrium state limits the amount of work that can be extracted on average from a system out of thermal equilibrium. This bound can be saturated by protocols putting the system and a bath into weak thermal contact (WTC), i.e., bringing the system into a Gibbs state at the bath's temperature. Surprisingly, the same bound holds true when the contact to the heat bath is modelled by more general proccesses, which have the only restriction that when the system already is in equilibrium, it cannot be brought out of it. In that sense, WTC is universal for work extraction.

In this work, we introduce the study of work-extraction protocols under restrictions encountered in realistic devices at the nano-scale. We consider limitations on the maximum energies in the system and on the local structure of many-body Hamiltonians. Remarkably, we find that WTC then loses its universality: There is a gap between the work the can be extracted with WTC and with more general operations. Our work highlights the relevance of operational frameworks such as those of thermal operations and Gibbs preserving maps, as they can improve the performance of thermal machines, and provides a unifying framework of incorporating natural restrictions in quantum thermodynamics.

Q 50.2 Thu 11:15 K/HS1

Wigner function for curved configuration spaces — •Clemens Gneiting[1], Timo Fischer[2], and Klaus Hornberger[2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg — [2]Universität Duisburg-Essen, Lotharstraße 1-21, 47057 Duisburg

We extend the Wigner-Weyl-Moyal phase-space formulation of quantum mechanics to general curved configuration spaces. The underlying phase space is based on the chosen coordinates of the manifold and their canonically conjugate momenta. The resulting Wigner function displays the axioms of a quasiprobability distribution, and any Weyl-ordered operator gets associated with the corresponding phase-space function. Moreover, the corresponding quantum Liouville equation reduces to the classical curved space Liouville equation in the semiclassical limit. We demonstrate the formalism for a point particle moving on two-dimensional manifolds, such as a paraboloid or the surface of a sphere.

Q 50.3 Thu 11:30 K/HS1

Scalable Reconstruction of Unitary Processes and Hamiltonians — •Milan Holzäpfel[1], Tillmann Baumgratz[1,2], Marcus Cramer[1], and Martin B. Plenio[1] — [1]Institut für Theoretische Physik, Albert-Einstein-Allee 11, Universität Ulm, 89069 Ulm, Germany — [2]Clarendon Laboratory, Department of Physics, University of Oxford, OX1 3PU Oxford, United Kingdom

Based on recently introduced efficient quantum state tomography schemes, we propose a scalable method for the tomography of unitary processes and the reconstruction of Hamiltonians [1]. As opposed to the exponential scaling with the number of subsystems of standard quantum process tomography, the method relies only on measurements of linearly many local observables and either (a) the ability to prepare eigenstates of locally informationally complete operators or (b) access to an ancilla of the same size as the to-be-characterized system and the ability to prepare a maximally entangled state on the combined system. As such, the method requires at most linearly many states to be prepared and linearly many observables to be measured. The quality of the reconstruction can be quantified with the same experimental resources that are required to obtain the reconstruction in the first place. Our numerical simulations of several quantum circuits and local Hamiltonians suggest a polynomial scaling of the total number of measurements and post-processing resources.

[1] M. Holzäpfel, T. Baumgratz, M. Cramer, and M.B. Plenio, arXiv:1411.6379

Q 50.4 Thu 11:45 K/HS1

A note on the relation between partial transpose, concurrence, and negativity — •Jens Siewert[1,2], Christopher Eltschka[3], and Géza Tóth[2,4,5] — [1]Department of Physical Chemistry, University of the Basque Country UPV/EHU, E-48080 Bilbao, Spain — [2]IKERBASQUE, Basque Foundation for Science, E-48013 Bilbao, Spain — [3]Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany — [4]Department of Theoretical Physics, University of the Basque Country UPV/EHU, E-48080 Bilbao, Spain — [5]Wigner Research Centre for Physics, Hungarian Academy of Sciences, H-1525 Budapest, Hungary

Detection of entanglement in bipartite states is a fundamental task in quantum information. The first method to verify entanglement in mixed states was the partial-transpose criterion. Subsequently, numerous quantifiers for bipartite entanglement were introduced, among them concurrence and negativity. Surprisingly, these quantities are often treated as distinct or independent of each other. The aim of this contribution is to highlight the close relations between these concepts, to show the connections between seemingly independent results, and to present various estimates for the mixed-state concurrence within the same framework.

Q 50.5 Thu 12:00 K/HS1

Constructing Entanglement Witnesses from Random Local Measurements — •Jochen Szangolies, Hermann Kampermann, and Dagmar Bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40255 Düsseldorf

The reliable and effective detection of entanglement is of paramount importance. However, given a random state, assessing its entanglement is a challenging task. To attack this problem, we investigate the use of random local measurements, from which entanglement witnesses are then constructed via semidefinite programming methods. We propose a scheme of progressively increasing the number of measurements until the presence of entanglement can be unambiguously concluded, and investigate its performance in various examples.

Q 50.6 Thu 12:15 K/HS1

On Categorical Characterizations of No-signaling Theories — •Mariami Gachechiladze — Universit\"at Siegen, Walter-Flex-Str. 3, 57068 Siegen, Germany — St Cross College, University of Oxford, OX1 3LZ, UK

Characterization of quantum and classical theories using information-theoretic constraints is one of the biggest areas of the theoretical research. In this contribution I investigate the correspondence between the kinematic independence of observables and the no-signaling principle. For that, I use the formalism of category theory and the graphical language. With the use of the diagrammatic language I show a construction to reason about no superluminal information transfer between two party systems in the presence of their physical independence. As a result, it is possible to prove that kinematic independence does not always entail no-signaling in the category of relations. In addition, I propose the potential paths to prove the converse implication but the further research is necessary to finalize it.

Q 50.7 Thu 12:30 K/HS1

Quantum-proof randomness extractors via operator space theory — Mario Berta[1], Omar Fawzi[2], and •Volkher B. Scholz[3] — [1]Institute for Quantum Information and Matter, Caltech, Pasadena, CA 91125, USA — [2]LIP, ENS de Lyon, 69364 Lyon, France — [3]Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland

Randomness extractors are an important building block for classical and quantum cryptography as well as for device independent randomness amplification and expansion. It is known that some constructions are quantum-proof whereas others are provably not [Gavinsky et al., STOC*07]. We argue that the theory of operator spaces offers a natural framework for studying to what extent objects are quantum-proof: we first rephrase the definition of extractors as a bounded norm condition between normed spaces, and then show that the presence of quantum adversaries corresponds to a completely bounded norm condition between operator spaces. Using semidefinite programming (SDP) relaxations of this completely bounded norm, we recover all known classes of quantum-proof extractors as well as derive new ones. Furthermore, we provide a characterization of randomness condensers (which correspond to a generalization of extractors) and their quantum-proof properties in terms of two-player games.

Q 50.8 Thu 12:45 K/HS1

Outcome strategies in geometric Bell inequalities — •Marcin Wiesniak, Arijit Dutta, and Junghee Ryu — Institute of Theoretical Physics and Astrophysics, University of Gdansk

Greenberger-Horne-Zeilinger states are intuitively known to be the most non-classical ones. They lead to the most radically nonclassical behavior of three or more entangled quantum subsystems. However, in case of two-dimensional systems, it has been shown that GHZ states lead to more robustness of Bell nonclassicality in case of geometrical inequalities than in case of Mermin inequalities. We investigate various strategies of constructing geometrical Bell inequalities (BIs) for GHZ states for any dimensionality of subsystems.