Q 16: Quantum Information (Concepts and Methods) III

Time: Tuesday 14:00–16:00 Location: e001

Q 16.1 Tue 14:00 e001

Wigner Process Tomography of Unknown Quantum Propagators — •Amit Devra and Steffen J. Glaser — Technische Universität München, Department Chemie, Lichtenbergstrasse 4, 85747 Garching, Germany

We study the tomography of unknown propagators for the spin system in the context of finite-dimensional Wigner representations, which completely characterize and visualize operators using shapes assembled from linear combinations of spherical harmonics. These shapes can be experimentally recovered by measuring the expectation values of the rotated axial tensor operator. Recent works show the general methodology to experimentally recover the shapes for density matrices (ρ) and known quantum propagators (U). This work extends the tomography approach for the unknown propagators. The approach is experimentally demonstrated for one-qubit quantum gates using NMR spectroscopy.

Q 16.2 Tue 14:15 e001

Entropy Production in Open Quantum Systems — •Nico Krause and Heinz-Peter Breuer — Albert-Ludwigs-Universität, Freiburg, Germany

On the basis of a random matrix model we investigate the degree of irreversibility of the dynamics of open quantum systems. Starting from the exact expression for the irreversible entropy production in terms of relative entropy, our central goal is the derivation of a suitable approximate expression which only refers to open system degrees of freedom. This expression depends on a freely choosable state ρ_s^0 of the open system. We present numerical simulations which demonstrate how this state has to be chosen. Furthermore, on the basis of various approximations an analytic derivation of the best choice for ρ_s^0 is developed. The result allows an efficient determination of the entropy production of quantum thermodynamic processes using information theoretical concepts in the regime of weak and intermediate coupling, and in the regime of high and intermediate temperatures.

Q 16.3 Tue 14:30 e001

Exploring the Limits of Open Quantum Dynamics: From Toy Models to Applications — •Frederik vom Ende[1], Gunther Dirr[2], and Thomas Schulte-Herbrüggen[1] — [1]TU Munich, 85748 Garching, Germany — [2]University of Würzburg, 97074 Würzburg, Germany

Which quantum states can be reached by coherently controlling n-level quantum systems coupled to a thermal bath in a switchable Markovian way?

We investigate the reachable sets of coherently controllable open quantum systems with switchable coupling to a thermal bath of arbitrary temperature T. The core problem boils down to studying points in the standard simplex with two types of amenable controls: (i) permutations within the simplex, (ii) contractions by a dissipative semigroup.

Our work focusses on how the solutions to the core problem pertain to the reachable set of the original controlled Markovian quantum system. We completely characterize the case $T = 0$ (amplitude damping) and present partial results for $0 < T < \infty$.

Moreover, one can structure the whole class of normal Lindblad generators in terms of reachability given full unitary control.

Q 16.4 Tue 14:45 e001

An exact approach to quantum non-Markovianity and entropy production in the Caldeira-Legget model — •Simon Einsiedler, Andreas Ketterer, and Heinz-Peter Breuer — Albert-Ludwigs-Universität, Freiburg, Germany

Employing the exact analytical solution of the Caldeira-Leggett model, a paradigmatic model for an open quantum system, we study the non-Markovian quantum dynamics for arbitrary couplings, temperatures and frequency cutoffs. Non-Markovianity is quantified using the Bures metric (fidelity) as distance measure for quantum states. This approach allows us to study quantum memory effects in the whole range from weak to strong dissipation. Furthermore we use a recently proposed expression for the entropy production in non-equilibrium processes to investigate the relation between mutual information and intra environment correlations for a finite number of bath modes.

Q 16.5 Tue 15:00 e001

Multiparticle entanglement detection on sector lengths — •Satoya Imai, Nikolai Wyderka, and Otfried Gühne — Naturwissenschaftlich-Technische Fakultät, Universität Siegen,Walter-Flex-Str. 3, D-57068 Siegen, Germany

Entanglement is one of the most striking phenomena in modern quantum physics. Its emerging properties have played a central role in applications of quantum information. Its generation has also been achieved experimentally, while actual noise effects make us not being sure if a created state is truly entangled. It is thus required to study how to detect entanglement.

We propose a theoretical method for entanglement detection in multiparticle qubit systems. We employ the concept of sector lengths, which can quantify the degree of quantum correlations and have the property of local unitary invariant. We show that the linear combinations of sector lengths can detect genuine multiparticle entanglement.

Q 16.6 Tue 15:15 e001

Positive maps and matrix contractions from the symmetric group — •Felix Huber — ICFO Barcelona, Spain

The study of polynomials that are positive on certain sets has a rich history, going back to Hilbert's seventeenth problem. Here we will look at multivariate polynomials (and more generally, tensor contractions) that have matrices as their variables. We present a family of maps that are positive on the positive cone. This extends the well-known concept of positive maps as used in entanglement theory to the multilinear case. We present connections to polynomial identity rings as well as central polynomials and show some applications in entanglement detection.

Q 16.7 Tue 15:30 e001

Chracterizing multipartite entanglement with moments of random correlations — •Andreas Ketterer[1,2], Nikolai Wyderka[2], and Otfried Gühne[2] — [1]Albert-Ludwigs Universität Freiburg, Freiburg, Germany — [2]Universität Siegen, Siegen, Germany

The trustworthy detection of multipartite entanglement usually requires a number of appropriately chosen local quantum measurements which are aligned with respect to a previously shared common reference frame. The latter, however, can be a challenging prerequisite, e.g., for satellite-based photonic quantum communication, making the development of alternative detection strategies desirable. In order to avoid the distribution of classical reference frames we follow a statistical treatment and show how to characterize multipartite entanglement with moments of correlation functions obtained from locally randomized measurements. To do so, we make use of spherical designs which link entanglement criteria based on moments to ordinary reference frame independent ones. The strengths of our methods are illustrated in various cases, starting with two qubits and followed by more involved multipartite scenarios.

[1] A. Ketterer, N. Wyderka, and O. Gühne, Phys. Rev. Lett. **122**, 120505 (2019)

Q 16.8 Tue 15:45 e001

Activating hidden metrological usefulness — •Géza Tóth[1,2,3,4], Tamás Vértesi[5], Paweł Horodecki[6,7], and Ryszard Horodecki[6,8] — [1]Theoretical Physics, University of the Basque Country UPV/EHU, E-48080 Bilbao, Spain — [2]Donostia International Physics Center (DIPC), E-20080 San Sebastián, Spain — [3]IKERBASQUE, Basque Foundation for Science, E-48011 Bilbao, Spain — [4]Wigner Research Centre for Physics, H-1525 Budapest, Hungary — [5]Institute for Nuclear Research, Hungarian Academy of Sciences, H-4001 Debrecen, Hungary — [6]International Centre for Theory of Quantum Technologies, University of Gdańsk, PL-80308 Gdańsk, Poland — [7]Faculty of Applied Physics and Mathematics, National Quantum Information Centre, Gdańsk University of Technology, PL-80233 Gdańsk, Poland — [8]Institute of Theoretical Physics and Astrophysics, National Quantum Information Centre, Faculty of Mathematics, Physics and Informatics, University of Gdańsk, PL-80308 Gdańsk, Poland

We consider entangled states that cannot outperform separable states in any linear interferometer. Then, we show that these states can still be more useful metrologically than separable states if several copies of the state are provided or an ancilla is added to the quantum system.

We present a general method to find the local Hamiltonian for which a given quantum state performs the best compared to separable states.