Q 46: Quantum Information (Concepts and Methods) IV

Time: Wednesday 14:00–16:15 Location: K 1.019

Q 46.1 Wed 14:00 K 1.019

Steering criteria from general entropic uncertainty relations — •Ana Cristina Sprotte Costa, Roope Uola, and Otfried Gühne — Universität Siegen, Siegen, Germany

Steering is a term coined by Schrödinger in 1935 in order to capture the essence of the Einstein-Podolsky-Rosen argument. It describes Alice's ability to affect Bob's quantum state through her choice of a measurement basis, without allowing for instantaneous signalling. We investigate a steering criteria from general entropic uncertainty relations and demonstrate that the resulting criteria outperform existing criteria in several scenarios. In this talk, we present the application of these criteria for different classes of bipartite systems, e.g. isotropic states, general two-qubit systems, bound entangled states. We also discuss the extension of these criteria for the multipartite case.

Q 46.2 Wed 14:15 K 1.019

Hypergraph states are universal resource states for measurement-based quantum computation — •Mariami Gachechiladze[1], Akimasa Miyake[2], and Otfried Gühne[1] — [1]University of Siegen, Siegen, Gemrnay — [2]University of New Mexico, Albuqueqrue, NM, USA

Hypergraph states form a family of multiparticle quantum states that generalizes graph states. We derive and utilize Pauli measurement rules to show that hypergraph states are novel resource states for measurement-based quantum computation with only Pauli measurements, additionally offering new schemes to parallelize quantum computation.

Q 46.3 Wed 14:30 K 1.019

New no-go theorems regarding phase space negativity and contextuality as resources — •Felipe Montealegre Mora, Huangjun Zhu, and David Gross — University of Cologne, Cologne, Germany

It has been proven recently that both negativity in the discrete Wigner function and contextuality with respect to stabilizer measurements may be considered resources in several variants of the model of quantum computing with magic states. They are also known not to be resources when working over qubits, and when including all operations taken from the stabilizer world into the model. This is arguably the most relevant case, as quantum algorithms are commonly understood in this framework.

Here we derive two new no-go theorems extending the results above. The first result considers phase space representations, a wider class of representations than discrete Wigner functions. We show that no phase space representation is covariant with respect to the real Clifford group. This result implies that negativity also fails to be a resource in this wider context whenever all real Clifford unitaries are part of the computational model. The second result considers a set of Pauli measurements subject to a certain uniformity condition. It is shown that if such a measurement set is large enough, then it contains some Clifford transform of the Mermin-Peres square with high probability.

Q 46.4 Wed 14:45 K 1.019

Continuous phase-space representations for finite-dimensional quantum states and their tomography — •Balint Koczor, Robert Zeier, and Steffen J. Glaser — Technische Universität München, Garching, Germany

Continuous phase spaces have become a powerful tool for describing, analyzing, and tomographically reconstructing quantum states in quantum optics and beyond. A plethora of these phase-space techniques are known, however a thorough understanding of their relations was still lacking for finite-dimensional quantum states. We present a unified approach to continuous phase-space representations which highlights their relations and tomography. The quantum-optics case is then recovered in the large-spin limit. Our results will guide practitioners to design robust innovative tomography schemes.

Q 46.5 Wed 15:00 K 1.019

Quantum random walks with step dependent coins — •Shahram Panahiyan[1] and Stephan Fritzsche[1,2] — [1]Helmholtz-Institut Jena, Germany — [2]Friedrich-Schiller-Universität Jena, Germany

A quantum random walk is a promising concept for simulating other quantum systems, developing quantum algorithms and exploring topological phases [1]. For these purposes, controllability over walker's probability density distribution is desired. Here, we study a particular type of quantum random walk which has a step dependent coin. It will be shown that with this setup, the walker could have diverse probability density distribution ranging from a complete localization to ballistic spread.

We have also investigated the Shannon entropy of this walk. The Shannon entropy is a tool for measuring the amount of uncertainty that is present in the state of a physical system [2]. This quantity could be used to determine the modification in amount of information of a physical system that goes through a process. It will be shown and explained how a rather irregular behavior arises for entropy of walks with a step dependent coin.

[1]: T. Kitagawa et al., Phys. Rev. A 82, 033429 (2010).
[2]: M. A. Nielsen et al., *Quantum computation and quantum information* (Cambridge University Press, 2010).

Q 46.6 Wed 15:15 K 1.019

Optimal catalytic quantum randomness — •Paul Boes, Henrik Wilming, Rodrigo Gallego, and Jens Eisert — Freie Universität Berlin

We investigate how much randomness is necessary to bring a system from one state to another state that is majorized by the initial one. We solve the problem completely by providing an optimal protocol showing that a maximally mixed state with dimension square-root of the system dimension is in general necessary and sufficient to implement such a state transition. The process we construct has the additional feature that the source of randomness is catalytic, i.e., remains in the maximally mixed state and can hence be re-used for different systems. We turn to considering several applications of this result, ranging from problems in decoherence and minimal measurement systems over scrambling of information to notions of cryptography. In particular, we introduce a novel cryptographic protocol, somewhat similar to superdense coding, with which two parties can communicate two classical bits securely over a public quantum channel of two qubits and a single private shared ebit. The protocol has the advantage that the ebit, after the two classical bits have been securely transmitted, returns exactly to its initial state and can be re-used to transmit further classical information securely. We also sketch how similar techniques can be used to establish a novel secret sharing scheme, where a given classical message can only be decoded if all parties of a given group consent. We complement the exact analysis of pinching maps with a discussion of approximate protocols based on quantum expanders.

Q 46.7 Wed 15:30 K 1.019

Recovery of quantum gates from few average gate fidelities — •Ingo Roth[1], Richard Kueng[2], Shelby Kimmel[3], Yi-Kai Liu[4], Jens Eisert[1], and Martin Kliesch[5] — [1]FU Berlin, Germany — [2]CalTech, USA — [3]Middlebury College, USA — [4]NIST, Gaithersburg, USA — [5]University of Gdańsk, Poland

One of the core tasks in quantum information science is the characterisation of quantum processes. But achieving this characterisation efficiently and accurately is a challenge. In this work, we consider using data from average gate fidelities to characterize quantum gates. Average gate fidelities are relatively easy to learn, and in some cases have additional robustness to state preparation and measurement errors. We show that any unital quantum channel can be affinely expanded in terms of any given unitary 2-design with coefficients determined by the average gate fidelities. Therefore $\mathcal{O}(d^4)$ average gate fidelities allow to uniquely determine a unital quantum channel acting on a d-dimenisonal Hilbert space. For the important case of characterizing multi-qubit unitary gates, we can further reduce this number to $\mathcal{O}(d^2 \log(d))$ average fidelities measured with respect to random Clifford gates, which are natural for many experiments. As a side result, we also obtain a novel statistical interpretation of the unitarity – a figure of merit that characterises the coherence of a noise process.

In our proofs we exploit new representation theoretic insights on the Clifford group, develop a version of Collins' calculus with Weingarten functions for integration over the Clifford group, and combine this with proof techniques from compressed sensing.

Q 46.8 Wed 15:45 K 1.019

Artificial Neural Network Representation of Spin Systems in a Quantum Critical Regime — •Stefanie Czischek, Martin Gärttner, and Thomas Gasenzer — Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany

We use the newly developed artificial-neural-network (ANN) representation of quantum spin-$\frac{1}{2}$ states based on restricted Boltzmann machines to study the dynamical build-up of correlations after sudden quenches in the transverse-field Ising model. We calculate correlation lengths and study their time evolution after sudden quenches from a large initial transverse field to different distances from the quantum critical point. By comparison with exact numerical solutions we show that in the close vicinity of the quantum critical point, where large correlations and volume-law entanglement are found, large network sizes are necessary to capture the exact dynamics. On the other hand we show a high accuracy of the network representation for quenches further away from the quantum critical point even for small network sizes scaling linearly with the system size. In these regimes the ANN representation shows promising results which suggest that the method may be efficiently used for not exactly solvable systems in one or higher dimensions.

Q 46.9 Wed 16:00 K 1.019

The static correlation paradox in quantum chemistry: a quantum information approach — Carlos Benavides-Riveros[1], Christian Schilling[2], and •Zoltán Zimborás[3] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle (Saale), Germany — [2]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, United Kingdom — [3]Wigner Research Centre for Physics, H-1525 Budapest, Hungary

In many scenarios in quantum chemistry, e.g., dissociation of molecules, there is only an asymptotically small interaction between different electrons, yet the ground state is very far from being a Slater determinant, i.e., an uncorrelated state. In this talk, we will treat this problem from a quantum information theoretic point of view. Giving first the proper definitions of different types of correlations (particle and mode correlations), taking also into account the parity and the particle-number superselection rules, we show that in this scenarios even a very small noise or temperature would make the state uncorrelated. Discussing the implication of this, we note that the result implies that in realistic set-ups the strong correlation of the state disappears, which may also hint to the possibility of improved numerical methods that can capture these scenarios.