Q 54: Quantum Information: Quantum Computing and Communication II

Time: Thursday 14:30–16:30 Location: e214

Q 54.1 Thu 14:30 e214

Measurement-device-independent randomness generation — •Felix Bischof, Hermann Kampermann, and Dagmar Bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany

The inherent unpredictability of quantum measurements provides a way to generate true objective randomness. However, the presence of unavoidable noise in any realistic setting requires careful separation of quantum randomness from classical pseudo-randomness. At the same time, the number of assumptions and explicit modelling of the devices should be low for any safe and practical scheme.

We introduce and analyze a measurement-device-independent scheme to generate true randomness with few assumptions: trusted sending devices send out qubit signals inside a secure laboratory. Upon receiving the signals, an uncharacterized measurement apparatus outputs classical bits, the raw random numbers. The observed measurement statistics is then used to quantify the amount of true randomness, independent of the inner working of the measurement device.

Q 54.2 Thu 14:45 e214

Randomized Benchmarking protocol accounting for leakage and gate dependent errors — •Tobias Chasseur and Frank Wilhelm — Theoretical Physics, Saarland University, 66123 Saarbrücken, Germany

In the wake of recent advances in experimental implementations of quantum gates on physical qubits characterizing the fidelity of those gates efficiently and accurately becomes increasingly important. The Randomized Benchmarking protocol allows to do so for specific sets of quantum gates such as the Clifford group in a way that is scalable in the number of qubits and robust against state preparation and measurements errors. It however suffers from several assumptions and restrictions which are typically not given for physical systems. We investigate the effect of leakage errors induced from an additional level per physical qubit on Randomized Benchmarking and provide a modified protocol that allows to derive reliable estimates for the average error per gate in their presence. Our protocol allows for gate dependent error channels without the unphysical restriction to small perturbations. We show that our protocol is compatible with Interleaved Randomized Benchmarking and expand to benchmarking of arbitrary gates. This setting is relevant for superconducting transmon qubits, among other systems.

Q 54.3 Thu 15:00 e214

Randomized benchmarking of one-qubit and two-qubit operations in an ion-trap quantum computer — •Alexander Erhard, Roman Stricker, Daniel Nigg, Esteban Martinez, Philipp Schindler, and Rainer Blatt — Institute for Experimental Physics, University of Innsbruck, Austria

Randomized benchmarking provides a platform independent approach to characterize the performance of a quantum computer. Large scale quantum computers require quantum error correction, which can be realized using operations from the Clifford group. Hence we investigate the fidelity of our quantum computer using only operations from the Clifford group. We present randomized benchmarking experiments on a single qubit and on two qubits. We estimate the fidelity of a single Clifford gate from the decay of the fidelity with increasing gate sequence length.

Q 54.4 Thu 15:15 e214

Consistency test for quantum process tomography — •Sabine Wölk — Department Physik, Universität Siegen, 57068 Siegen, Germany

Quantum channels are in general described by completely-positive maps $\mathcal{E}$. However, when performing quantum process tomography, often non-positive maps appear.

There exist several reason for the emersion of non-positive maps in quantum process tomography: (i) statistical errors due to the limited number of measurements, or systematic errors such as e.g. (ii) misaligned measurements or (iii) initial correlation of the system and the environment [1,2].

In this talk we will discuss the reasons for the appearance of not completely-positive maps. Furthermore, we introduce methods to distinguish statistical and systematic errors in process tomography based on methods from state tomography [3].

[1] P. Pechukas, Phys. Rev. Lett. **73**, 1060 (1994).
[2] C. Wood, Honours thesis, Macquarie University, Sydney, Australia (2009), arXiv:0911.3199.
[3] T. Moroder, M. Kleinmann, P. Schindler, T. Monz, O. Gühne, and R. Blatt, Phys. Rev. Lett. **110**, 180401 (2013).

Q 54.5 Thu 15:30 e214

Contextuality as a resource for qubit quantum computation — Robert Raussendorf[1], Dan E. Browne[2], Nicolas Delfosse[3,4,5], Cihan Okay[6], and •Juan Bermejo-Vega[7,8] — [1]Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada — [2]Department of Physics and Astronomy, University College London, Gower Street, London, UK — [3]Departement de Physique, Universite de Sherbrooke, Sherbrooke, Quebec, Canada — [4]IQIM, California Institute of Technology, Pasadena, CA, USA — [5]Department of Physics and Astronomy, University of California, Riverside, California, 92521, USA — [6]Department of Mathematics, University of Western Ontario, London, Ontario, Canada — [7]Max-Planck Institut fuer Quantum Optics, Theory Division, Garching, Germany — [8]Dahlem Center for Complex Quantum Systems, Freie Universitaet Berlin, Berlin, Germany

We describe a scheme of quantum computation with magic states on qubits for which contextuality is a necessary resource possessed by the magic states. More generally, we establish contextuality as a necessary resource for all schemes of quantum computation with magic states on qubits that satisfy three simple postulates. Furthermore, we identify stringent consistency conditions on such computational schemes, revealing the general structure by which negativity of Wigner functions, hardness of classical simulation of the computation, and contextuality are connected.

Based on http://arxiv.org/abs/1511.08506

Q 54.6 Thu 15:45 e214

Atomic two-qubit quatum operations assisted by multiphoton states — •Juan Mauricio Torres, József Zsolt Bernád, Ludwig Kunz, and Gernot Alber — Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Germany

We compare two schemes to implement quantum operations on atomic qubits. In one of them two two-level atoms interact one after the other with the electromagnetic field inside an optical resonator. In the second scheme, the two atoms interact simultaneously with the optical field. We show that in both cases, two-qubit entangling operations can be performed by measuring the field state inside the resonator with a balanced homodyne detection. To complete the description we analyze the effects of photon losses in the performance of the protocol.

Q 54.7 Thu 16:00 e214

Performance analysis of large-scale quantum networks based on graphs — •Michael Epping, Hermann Kampermann, and Dagmar Bruss — Heinrich-Heine-Universität Düsseldorf, Institut für Theoretische Physik III, Düsseldorf

Quantum repeaters effectively reduce the error rates (i.e. the noise and erasures) of transmission channels, which is a necessary prerequisite of any long distance quantum communication protocol. A quantum network, containing such channels to connect the participants, can be associated with a mathematical graph. Here, each vertex corresponds to a party and each edge to a line of repeater stations.

We analyze the propagation of errors in a quantum network [1]. In particular we focus on the production of graph states shared by all parties - a natural resource of multipartite entanglement in a quantum network. Finally we show how our approach leads to schemes which efficiently employ the infrastructure of a given quantum network.

[1] M.E., H.K., and D.B., arXiv:1508.02185 [quant-ph]

Q 54.8 Thu 16:15 e214

Quantum state merging with bound entanglement — •Alexander Streltsov — Freie Universität Berlin

Quantum state merging is one of the most important protocols in quantum information theory. In this task two parties aim to merge their parts of a pure tripartite state by making use of additional singlets while preserving coherence with a third party. We study a variation of this scenario where the merging parties have free access to PPT entangled states, and the total quantum state shared by all three parties is not necessarily pure. We provide general conditions for a state to admit perfect merging, and present a family of fully separable states which cannot be perfectly merged if the merging parties have no access to additional singlets. We also show that for pure states the conditional entropy plays the same role as in standard quantum state merging, quantifying the amount of quantum communication needed to perfectly merge the state. While the question whether the protocol considered here exhibits the strong converse property is left open, it is shown that for a significant amount of quantum states the merging fidelity vanishes asymptotically.