QI 17: Quantum Networks I (joint session QI/Q)

Time: Wednesday 11:00–12:45 Location: B305

Invited Talk QI 17.1 Wed 11:00 B305

Self-testing with dishonest parties and entanglement certification in quantum networks — •Gláucia Murta[1] and Flavio Baccari[2] — [1]Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, Garching 85748, Germany

Multipartite entanglement is a crucial resource for network cryptographic tasks, such as secret sharing and anonymous quantum communication. Here, we consider the task of entanglement verification in a quantum network. The goal is to certify entanglement of the distributed state even when some of the parties (an unknown subset of parties in the network) may act maliciously. Our main result is a device-independent verification protocol that can certify genuine multipartite entanglement in the presence of dishonest parties. Our protocol is based on the Svetlichny inequality, and we show that the maximal violation of the Svetlichny inequality can self-test the GHZ state even in the presence of dishonest parties.

QI 17.2 Wed 11:30 B305

Extracting maximal entanglement from linear cluster states — •Jarn de Jong[1], Frederik Hahn[1], Nikolay Tcholtchev[2], Manfred Hauswirth[2], and Anna Pappa[1,2] — [1]Electrical Engineering and Computer Science Department, Technische Universitaet Berlin, 10587 Berlin, Germany — [2]Fraunhofer Institute for Open Communication Systems - FOKUS, 10589 Berlin, Germany

Most quantum information processing architectures only allow for nearest-neighbour entanglement creation. In many cases, this prevents the direct generation of maximally entangled states, which are commonly used for many communication and computation tasks. Here we show how to obtain maximally entangled GHZ states between vertices initially connected by a minimum number of connections, which specifically allows them to share linear cluster states. We prove that the largest GHZ state that a linear cluster state on n qubits can be transformed into by means of local Clifford unitaries, local Pauli measurements and classical corrections, is of size $\lfloor (n+3)/2 \rfloor$. We demonstrate exactly which qubit selection patterns are possible below this threshold and which are not, and implement the transformation on the `IBMQ Montreal` quantum device for linear cluster states of up to $n = 19$ qubits.

QI 17.3 Wed 11:45 B305

Aging effects in multiplexed quantum networks — •Lisa T. Weinbrenner[1], Lina Vandré[1], Tim Coopmans[2], and Otfried Gühne[1] — [1]Universität Siegen, Germany — [2]Universiteit Leiden, Netherlands

Aging is a well known problem which effects humans as well as technical devices. It is described by the effect that the probability for a failure in a given time interval increases with the life time of the biological or technological object. Different types of objects (e.g. humans and technical devices) age according to qualitatively different failure rates. The difference can be understood if these objects are modeled as systems of redundant parts with possibly initial defects [1].

Multiplexed quantum networks are quantum networks with multiple connections between two nodes, i.e., with redundancy in the edges of the network [2]. The functionality of the entire network depends on the functionality of the technical devices used. This leads to the question how the failure rates of the single devices lead to aging effects in the entire network. In this contribution we will apply the theory of aging to the technical devices used in a multiplexed quantum network. Our results rely on the analytical treatment of the underlying stochastic process of failure of the devices, as well as numerical simulations for different network structures.

[1] L. A. Gavrilov and N. S. Gavrilova, J. Theor. Biol. 213, 527-545 (2001)

[2] O. A. Collins et al., Phys. Rev. Lett 98, 060502 (2007)

QI 17.4 Wed 12:00 B305

Cavity-Assisted Entanglement Generation between Spins and Photon Pulses — •Ferdinand Omlor, Benedikt Tissot, and Guido Burkard — Department of Physics, University of Konstanz, D-78457 Konstanz, Germany

The reliable entanglement generation between distant nodes of a quantum network is a core challenge for the realization of quantum communication. Spin qubits contained in optical cavities are promising systems which can be interconnected by photons using fiber optics. So far the focus of theoretical studies was on single modes. We present a way to study multimode signals, in particular pulses of finite duration. This multimode character needs to be taken into account to correctly calculate the fidelity of entanglement generation between a single photon pulse and a spin qubit. We specifically study this with the network architecture proposed by K. Nemoto et al., Phys. Rev. X 4, 031022 (2014) in mind.

QI 17.5 Wed 12:15 B305

A Graphical Formalism for Entanglement Purification — •Lina Vandré and Otfried Gühne — Universität Siegen, Germany

Hypergraph states form an interesting family of multi-qubit quantum states which are useful for quantum error correction, non-locality and measurement-based quantum computing. They are a generalisation of graph and cluster states. The states can be represented by hypergraphs, where the vertices and hyperedges represent qubits and entangling gates, respectively.

For quantum information processing, one needs high-fidelity entangled states, but in practice most states are noisy. Purification protocols address this problem and provide a method to transform a certain number of copies of a noisy state into single high-fidelity state. There exists a purification protocol for hypergraph states [1]. In my talk, I will first reformulate the purification protocol in a graphical manner, which makes it intuitively understandable. Based on this, I will propose systematic extensions, which naturally arise from the graphical formalism.

[1] T. Carle et al., Phys. Rev. A 87, 012328 (2013)

QI 17.6 Wed 12:30 B305

Generation of multidimensional entanglement in quantum optical systems — •Felix Twisden-Peareth, Jan Sperling, and Polina Sharapova — Paderborn University, Warburger Str. 100 | 33098 Paderborn

Multidimensional entanglement is a key source for many quantum applications, such as quantum computing, quantum communication and quantum simulation [1].

In this work, we investigate a four-channeled quantum optical system, which is driven by two spontaneous parametric down-conversion (SPDC) sources (each emitting two photons), in order to find configurations that generate maximal entanglement. The entanglement is quantified by the Schmidt number $\mathrm{K} = \mathrm{Tr}[\rho_r^2]^{-1}$, which is applicable to both pure and mixed states [2]. In our system, to calculate the Schmidt number, we provide reductions regarding both frequencies and spatial channels. In order to affect the entanglement, the photons in the system are manipulated regarding their polarization and relative position by introducing a time delay. It was found that Schmidt numbers equal to the dimensionality of the system can be generated. For this, the generation of a coherent superposition of different polarizations is provided, which is followed by a temporal separation of its parts. All results are calculated for the material system $LiNbO_3$.

[1] J. Wang, et al., Multidimensional quantum entanglementwith large-scale integrated optics, Science **360**, 285*291 (2018).

[2] B. M. Terhal and P. Horodecki, Schmidt number for density matrices, Physical Review A **61**, 040301 (2000).