Q 23: Quantum Information: Concepts and Methods IV

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

Q 23.1 Tue 14:30 e214

The Computational Complexity of Multiboson Correlation Interference — •Simon Laibacher and Vincenzo Tamma — Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQ^{ST}), Universität Ulm, D-89069 Ulm, Germany

In our talk, we demonstrate that a computational power beyond any classical capabilities can be achieved in bosonic linear interferometers even with nonidentical photons [1]. This approach overcomes the challenge of generating identical bosons, which so far have been essential in quantum information processing, including the well-known problem of boson sampling [2].

In contrast to the original formulation of boson sampling, we investigate MultiBoson Correlation Sampling, where time-resolved sampling measurements at the interferometer output are performed [3,4]. Interestingly, even with photons of completely different colors this problem is at least as computationally hard as the original boson sampling problem with identical photons[1].

These results demonstrate the quantum computational supremacy inherent in the fundamental nature of quantum interference [3].

[1] Laibacher and Tamma, in press in Phys. Rev. Lett. (2015)
[2] Aaronson and Arkhipov, in *Proceedings of the 43rd annual ACM symposium on Theory of computing* (ACM, 2011) pp. 333–342
[3] Tamma and Laibacher, Phys. Rev. Lett. **114**, 243601 (2015)
[4] Tamma and Laibacher, Quantum Inf. Proc. (2015). DOI:10.1007/s11128-015-1177-8

Q 23.2 Tue 14:45 e214

Imaging two-dimensional source geometries using higher order spatial photon correlations — •Anton Classen[1,2], Felix Waldmann[1], Raimund Schneider[1,2], Thomas Mehringer[1,2], and Joachim von Zanthier[1,2] — [1]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, 91058 Erlangen — [2]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Universität Erlangen Nürnberg, 91052 Erlangen)

Measuring higher order correlation functions is an emerging technique in the field of imaging to overcome the classical resolution limit [1-3]. We propose to use higher order spatial correlations of photons emitted by independent classical sources with thermal statistics to implement an imaging technique capable of reconstructing arbitrary two-dimensional source geometries. The detection scheme generalizes our earlier imaging scheme which resolved one-dimensional source geometries with sub-Abbe resolution [3]. The scheme is able to isolate all spatial frequencies of the system sequentially what allows to retrieve the geometry of the sources. We present experimental data verifying the theory.

[1] M. E. Pearce et al., Precision estimation of source dimensions from higher-order intensity correlations, Phys. Rev. A 92, 043831 (2015)
[2] D. G. Monticone et al., Beating the Abbe Diffraction Limit in Confocal Microscopy via Nonclassical Photon Statistics, Phys. Rev. Lett. 113, 143602 (2014)
[3] S. Oppel et al., Superresolving Multiphoton Interferences with Independent Light Sources, Phys. Rev. Lett. 109, 233603 (2012)

Q 23.3 Tue 15:00 e214

Quantumness of spin-1 states — Fabian Bohnet-Waldraff[1,2], •Daniel Braun[1], and Olivier Giraud[2] — [1]Institute of theoretical physics, University Tübingen, 72076 Tübingen — [2]LPTMS, CNRS, Univ. Paris-Sud, Université Paris-Saclay, 91405 Orsay, France

We derive an analytic expression for the quantumness of pure spin-1 states, which measures the degree of non-classicality of a quantum state. Quantumness is defined as the Hilbert-Schmidt distance to the convex hull of SU(2)-coherent states. These spin coherent states play the role of pure classical states, while their convex hull defines the set of mixed classical states. Our formula expresses the quantumness of a state in terms of the smallest eigenvalue of its Bloch matrix. The proof of the formula is based on explicitly constructing the closest classical state. We give numerical evidence that the exact formula for pure states, when evaluated at the smallest eigenvalue of the Bloch matrix of some mixed state, provides an upper bound on the quantumness of that state. Finally, by relating the set of two-qubit symmetric separable states to the set of classical spin-1 states, we make a connection to the theory of entanglement: the quantumness of a pure spin-1 state is linked, through a rather complicated function that we provide explicitly, to the negativity of the state. For mixed states the same function serves as upper bound of the quantumness.

Q 23.4 Tue 15:15 e214

Characterising ground and thermal states of few-body Hamiltonians — •Felix Huber and Otfried Gühne — Universität Siegen

Hamiltonians of naturally occuring physical systems are expected to have few-body interactions only. Accordingly, these Hamiltonians impose only local constraints onto the quantum states governed by them. Thus motivated, we characterise the set of ground and thermal states of few-body Hamiltonians, leading to new insights into the quantum marginal problem and to a generalisation of entanglement. We provide both witnesses as well as a semi-definite program to detect states outside of the convex hull of thermal and ground states having few-body Hamiltonians only. Finally, we give numerical results on the fraction of pure states determined by their marginals, and explore connections to the detection of topologically ordered states.

Q 23.5 Tue 15:30 e214

Non-equidistant dynamical decoupling and weighted Cesàro means — •József Zsolt Bernád — Institut für Angewandte Physik, TU Darmstadt, Germany

Dynamical decoupling is a method which decouples quantum systems from their environments and increases the coherence times of the quantum states. One possibility to optimize the suppression of the decoherence is to use non-equidistant pulse sequences, like Uhrig's dynamical decoupling scheme. We investigate this problem from a general point of view and relate to ergodic theorems and weighted Cesàro means. We show that in the limit of continuous control the suppression mechanism becomes independent from the non-equidistant timing of the pulses. In the case of finite number of pulses an inequality is derived and within this approach the non-equidistant application of the pulses is optimized.

Q 23.6 Tue 15:45 e214

One-to-one mapping between steering and joint measurability problems — •Roope Uola[1], Costantino Budroni[1], Otfried Gühne[1], and Juha-Pekka Pellonpää[2] — [1]Universität Siegen, Siegen, Germany — [2]Turku Centre for Quantum Physics, Turku, Finland

Quantum steering refers to a quantum information task where one party, say Alice, tries to remotely steer another party's, say Bob's, state by performing local measurements on her half of a bipartite system. Two necessary ingredients for steering are entanglement and incompatibility of Alice's measurements. In particular, it has been recently proven that for the case of pure states of maximal Schmidt rank the problem of steerability is equivalent to the problem of joint measurability for Alice's observables. We show that such an equivalence holds in general, namely, the steerability of any assemblage can always be formulated as a joint measurability problem, and vice versa. We use this connection to introduce steering inequalities from joint measurability criteria and develop quantifiers for the incompatibility of measurements.

Q 23.7 Tue 16:00 e214

Simultaneous gates in frequency-crowded multilevel systems using fast, robust analytic control shapes — •Lukas S. Theis, Felix Motzoi, and Frank K. Wilhelm — Saarland University, 66123 Saarbrücken, Germany

We present a few-parameter ansatz for pulses to implement simultaneous single-qubit rotations in frequency–crowded multi-level systems. Specifically, we consider a system of two qutrits whose working and leakage transitions suffer from spectral crowding (detuned by δ). In order to achieve precise controllability, we make use of two driving fields (each having two quadratures) at two different tones to simultaneously apply arbitrary combinations of rotations about axes in the X–Y plane to both qubits. Expanding the waveforms in terms of Hanning windows, we show how analytic pulses containing smooth and composite-pulse features can easily achieve gate errors $< 10^{-4}$ and considerably outperform known adiabatic techniques. Moreover, we find a generalization of the WahWah method [Phys. Rev. A **88**, 052330

(2013)] that allows precise separate single-qubit rotations for all gate times beyond a quantum speed limit. We find in all cases a quantum speed limit slightly below $2\pi/\delta$ for the gate time and show that our pulses are robust against variations in system parameters and filtering due to transfer functions, making them suitable for experimental implementations.

Q 23.8 Tue 16:15 e214

The Magic of Combining Coherent Control with Switchable Noise — •Thomas Schulte-Herbrüggen[1], Ville Bergholm[1,2], and Frank Wilhelm[3] — [1]Technical University of Munich (TUM) — [2]University of Helsinki — [3]University of Saarbrücken

Combining coherent control with simplest noise control seems magic: it allows to *interconvert arbitrary quantum states* no mattter whether they are pure or mixed. We sketch possible experimental implementation in superconducting devices.

We analyse the capabilities of switchable noise in view of the limits between open-loop control and closed-loop feedback control.

All these findings fit nicely in a Lie-geometric picture of dynamic systems control.