Q 61: Quantum Information: Concepts and Methods 4

Time: Friday 10:30–13:00 Location: SCH A118

Q 61.1 Fri 10:30 SCH A118

Phase-dependent wave-particle duality and delayed choice of the which-way detector observable — •Uwe Schilling and Joachim von Zanthier — Institut für Optik, Information und Photonik and Erlangen Graduate School in Advanced Optical Technologies (SAOT), Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

It is well-known that when probing wave-particle duality in a two-way interferometer with a which-way detector, the amount of which-way information (WWI) depends on the observable which one reads out from the which-way detector. One may for example extract all WWI principally available [1] or, contrariwise, realize a quantum eraser [2] which erases all WWI. We introduce a still different observable which allows to either fully reveal or partially erase the WWI, depending on the phase shift in the interferometer [3]. In particular, for particles arriving in the minima of an interference pattern with $\mathcal{V} < 1$, the new observable enables us to extract full WWI which seems to contradict the inequality $\mathcal{D}^2 + \mathcal{V}^2 \leq 1$ introduced in Ref. [1]. We resolve this ostensible contradiction for the case that only the new observable is measured [3]. However, we also show that $\mathcal{D}^2+\mathcal{V}^2 \leq 1$ may be violated by adeptly choosing the observable which is to be measured after the particle has been detected [4].

[1] B.-G. Englert, Phys. Rev. Lett. **77**, 2154 (1996)
[2] M. O. Scully and K. Drühl, Phys. Rev. A **25**, 2208 (1982)
[3] U. Schilling and J. von Zanthier, to be published
[4] U. Schilling and J. von Zanthier, quant-ph/1006.2037 (2010)

Q 61.2 Fri 10:45 SCH A118

Shor's algorithm and the factorization with Gauss sums — •Sabine Wölk and Wolfgang Schleich — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

Shor's algorithm is one of the famous algorithms which scales polynomial whereas analog computers need exponential time to solve the same problem. However, Shor's algorithm does not factor numbers, it just find periods.

On the other side, there exist functions other than a^ℓ mod N used in Shor's algorithm whose period also contains information about the factors of N. One of these functions is the standard Gauss sum.

In our talk, we will discuss the problems and improvements which emerge when we replace in Shor's algorithm the function a^ℓ mod N by the standard Gauss sum. Furthermore, we show that the periodicity must not occur in the states itself, but can also appear in the probability amplitudes.

Q 61.3 Fri 11:00 SCH A118

Uncertainty relations and the graph state formalism — •Sönke Niekamp, Matthias Kleinmann, and Otfried Gühne — Fachbereich Physik, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen

Uncertainty relations not only describe a fundamental concept of quantum mechanics, but also have found application in quantum cryptography and entanglement detection. Entropic uncertainty relations have turned out to be particularly useful. Central questions here are the characterization of observables yielding strong uncertainty relations and the extension to the case of more than two observables. We demonstrate how the stabilizer or graph state formalism can be applied to these problems. For an arbitrary number of qubits we construct measurement bases for which the Maassen-Uffink entropic uncertainty relation is tight. We compare the relative strengths of variance-based and various entropic uncertainty relations for dichotomic anticommuting observables and discuss the generalization to other classes of observables.

Q 61.4 Fri 11:15 SCH A118

A Simple Construction of Cyclic Mutually Unbiased Bases — •Ulrich Seyfarth[1], Kedar Ranade[2], and Gernot Alber[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [2]Institut für Quantenphysik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm, Germany

Many applications of complete sets of mutually unbiased bases (MUBs) in the field of quantum information theory are known. In particular, in the context of quantum cryptography they yield generalizations of the six-state protocol for qubits. Recently it was shown that in even prime-power dimensions such MUBs can be generated by a single unitary operator [1,2] so that they are 'cyclic'. In this contribution we present a method for constructing cyclic MUBs in higher dimensions recursively. This method enables one to construct generators of complete sets of cyclic MUBs for very high dimensions without elaborate numerical calculation. These results may be relevant for high-dimensional generalizations of the quantum cryptographic six-state protocol as well as possible applications in quantum state discrimination.

[1] H. F. Chau, IEEE Trans. Inf. Theory 49, 457 (2003)
[2] R. Gow, arXiv:math/0703333v2 (2007)

Q 61.5 Fri 11:30 SCH A118

Optimal molecular networks for excitonic energy transport — •Torsten Scholak, Thomas Wellens, and Andreas Buchleitner — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg, Germany

Our study of coherent excitation transfer in finitely sized disordered molecular networks reveals certain optimal conformations that feature fast and perfectly efficient transport of energy—solely by means of constructive quantum interference. The properties and mechanics of these remarkable conformations are the subject of this talk. Our insights may help to better understand the efficient energy transfer in photosynthetic light-harvesting complexes.

Q 61.6 Fri 11:45 SCH A118

Classical simulation of dynamical quantum systems — •Robert Zeier — Technische Universität München, Department Chemie, Lichtenbergstr. 4, 85747 Garching

We propose Lie-algebraic methods to simulate unitary dynamics of closed quantum systems using classical computers. A wide range of approaches represent mixed quantum states and unitary transformations by explicit matrices which are assumed to be sparse. In contrast, we rely on direct computations in structure-constant Lie algebras where Lie-algebra elements are given as sparse vectors and the commutator is efficiently implemented while accounting for sparsity. Building on this representation, we present a method to compute the time evolution which avoids direct matrix exponentiation. We discuss the efficiency of our methods.

Q 61.7 Fri 12:00 SCH A118

How contextual is quantum mechanics? — •Matthias Kleinmann[1], Otfried Gühne[1], José Portillo[2], Jan-Åke Larsson[3], and Adán Cabello[4] — [1]Fachbereich Physik, Universität Siegen, D-57068 Siegen, Germany — [2]Departamento de Mathemática Aplicada I, Universidad de Sevilla, E-41012 Sevilla, Spain — [3]Institutionen för Systemteknik och Matematiska Institutionen, Linköpings Universitet, SE-581 83 Linköping, Sweden — [4]Departamento de Física Aplicada II, Universidad de Sevilla, E-41012 Sevilla, Spain

The Kochen-Specker theorem proves that any classical model of quantum mechanics necessarily is contextual, i.e., the value of an observable depends on which other, compatible observable is measured simultaneously. We investigate classical models that simulate quantum contextuality for sequential measurements. Such models can be described by means of finite automata and we quantify the number of different states an automaton obtains during a measurement sequence as being the memory need of the automaton. We analyze this memory need for different scenarios and show that the simulation of a two-qubit system can require more than two bits of classical memory.

Q 61.8 Fri 12:15 SCH A118

Quantum Simulation by Example: Exploiting Symmetry Principles of Quantum Systems Theory — •Thomas Schulte-Herbrüggen and Robert Zeier — Dept. Chem., TU-Munich, Germany

We present a plethora of examples showing under which conditions spin systems, fermionic systems, and bosonic systems with pair or higher many-body interactions can mutually simulate eachother.

These illustrations are part of a unified framework of quantum systems theory, where symmetry principles translate into simple algorithms deciding engineering problems of controllability, observability, and the design of universal quantum hardware.

Q 61.9 Fri 12:30 SCH A118

Performance of quantum convolutional and block error-correcting codes — •Johannes Gütschow — Institut für Theoretische Physik, Universität Hannover

Quantum convolutional error-correcting codes are often said to have the potential to outperform block codes in terms of code rate and decoding complexity. In this talk we will compare the performance of convolutional codes and block codes under constraints on the size of the encoding and decoding operations (the block length). We will analyze the relation between code rate, the correctable error rate and the block length.

We will first derive a Hamming type bound on the number of correctable errors per block for convolutional codes. Using this bound in different settings we will compare the theoretical performance of convolutional codes to that of block codes and finally give examples for convolutional codes in these settings.

Q 61.10 Fri 12:45 SCH A118

Differencial Magnetometry with Multipartite Singlets — •Iñigo Urizar-Lanz[1] and Géza Tóth[1,2,3] — [1]Theoretical Physics, The University of the Basque Country, E-48080 Bilbao, Spain — [2]IKERBASQUE, Basque Foundation for Science, E-48011 Bilbao, Spain — [3]Research Institute for Solid State Physics and Optics, H-1525 Budapest, Hungary

We present a method for measuring the gradient of a magnetic field using a multi-qubit singlet state taking advantage of the fact that the singlet state is insensitive to homogenous fields. By measuring the time dependence of the variance of the collective angular momentum operators, we obtain the gradient of the magnetic field. We present realistic calculations for singlet states realized in a spin chain or with cold atomic ensembles.