Q 4: Quantum Information: Concepts and Methods I

Time: Monday 14:00–16:00 Location: E 214

Q 4.1 Mo 14:00 E 214

A novel number operator-annihilation operator uncertainty relation and its use for entanglement detection — •Iñigo Urizar Lanz[1] and Geza Toth[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 consider the number operator-annihilation operator uncertainty as a well behaved alternative of the number-phase uncertainty relation, and examine its properties. We find a formulation in which the bound on the product of uncertainties depends on the expectation value of the particle number. Thus, while the bound is not a constant, it is a quantity that can be easily controlled in many systems. The uncertainty relation is approximately saturated by number-phase intelligent states. It allows us to define amplitude squeezing, connecting coherent states to Fock states, without a reference to a phase operator. We consider using the uncertainty relation for entanglement detection.

Q 4.2 Mo 14:15 E 214

All reversible dynamics in maximally non-local theories are trivial — David Gross[1], •Markus Mueller[2], Roger Collbeck[3], and Oscar Dahlsten[3] — [1]Leibniz-Universitaet Hannover — [2]TU Berlin — [3]ETH Zuerich

A remarkable feature of quantum theory is non-locality (i.e. the presence of correlations which violate Bell inequalities). However, quantum correlations are not maximally non-local, and it is natural to ask whether there are compelling reasons for rejecting theories in which stronger violations are possible. To shed light on this question, we consider post-quantum theories in which maximally non-local states (non-local boxes) occur. It has previously been conjectured that the set of dynamical transformations possible in such theories is severely limited. We settle the question affirmatively in the case of reversible dynamics, by completely characterizing all such transformations allowed in this setting. We find that the dynamical group is trivial, in the sense that it is generated solely by local operations and permutations of systems. In particular, no correlations can ever be created; non-local boxes cannot be prepared from product states (in other words, no analogues of entangling unitary operations exist), and classical computers can efficiently simulate all such processes.

Q 4.3 Mo 14:30 E 214

Almost compatible observables in quantum tests of contextuality — Otfried Gühne[1,2], •Matthias Kleinmann[1], Adán Cabello[4], Jan-Ake Larsson[5], Gerhard Kirchmair[1,3], Florian Zähringer[1,3], Rene Gerritsma[1,3], Rainer Blatt[1,3], and Christian Roos[1,3] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck, Austria — [2]Institut für Theoretische Physik, Universität Innsbruck, Austria — [3]Institut für Experimentalphysik, Universität Innsbruck, Austria — [4]Departamento de Física Aplicada II, Universidad de Sevilla, Spain — [5]Institutionen för Systemteknik och Matematiska Institutionen, Linköpings Universitet, Sweden

The Kochen-Specker-Theorem proves that in a hidden variable description of a quantum system, the value of a particular property (observable) depends on the context in which the value is to be revealed. The conflict here is between the hidden variable approach and the theory of quantum mechanics.

In order to establish this conflict as the inability to employ a hidden variable description of an actual experiment, it has been suggested to extend the notion of non-contextuality to sequential measurements of compatible observables. However, in an experimental implementation the requirement of perfect compatibility cannot be reached. We show that this "compatibility loophole" can be addressed and that a recent experiment using tapped ions [G. Kirchmair *et al.*, Nature (London) **460**, 494 (2009)] then excludes a large class of non-contextual hidden variable models.

Q 4.4 Mo 14:45 E 214

Quantum state tomography via compressed sensing — •David Gross[1], Yi-Kai Liu[2], Steve Flammia[3], Stephen Becker[4], and Jens Eisert[5] — [1]Leibniz-Universitaet Hannover — [2]California Institute of Technology — [3]Perimeter Institute for Theoretical Physics — [4]California Institute of Technology — [5]Universitaet Potsdam

We establish novel methods for quantum state and process tomography based on compressed sensing. Our protocols require only simple Pauli measurements, and use fast classical post-processing based on convex optimization. Using these techniques, it is possible to reconstruct an unknown density matrix of rank r using $O(rd \log d)$ measurement settings, a significant improvement over standard methods that require d^2 settings. The protocols are stable against noise, and extend to states which are approximately low-rank. The acquired data can be used to certify that the state is indeed close to a low-rank one, so no *a priori* assumptions are needed.

At the same time, new mathematical methods for analyzing the problem of low-rank matrix recovery have been obtained. The methods are both considerably simpler, and more general than previous approaches. It is shown that an unknown $d \times d$ matrix of rank r can be efficiently reconstructed given knowledge of only $O(dr \log^2 d)$ randomly sampled expansion coefficients with respect to any given matrix basis.

Q 4.5 Mo 15:00 E 214

Convex Polytopes and Quantum States — •colin wilmott, hermann kampermann, and dagmar bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, Düsseldorf

A *convex polytope* is defined as the convex hull of a finite non-empty set of vectors. We present a theorem of Rado (1952) which characterizes the convex hull of the collection of all permutations of a given real d-tuple in terms of the Hardy-Littlewood-Pólya spectral order relation $\prec$. We give a necessary and sufficient condition to construct a d-dimensional convex polytope which utilizes Rado's original $(d-1)$-dimensional characterization, and we describe how the resulting polytope may be placed in a quantum mechanical framework.

Q 4.6 Mo 15:15 E 214

Mapping between Kitaev's quantum double and the Levin-Wen spin net — •Zoltan Kadar[1], Annalisa Marzuoli[2], and Mario Rasetti[1,3] — [1]ISI Foundation, Torino, Italy — [2]University of Pavia, Italy — [3]Politecnico di Torino, Italy

Duality in lattice gauge theory is an equivalence of different descriptions of states living on the lattice. Kitaev's model is the description in terms of the (gauge) group algebra basis, the Levin-Wen spin net is that in the Fourier (a.k.a. spin network) basis. The construction is explicit for the ground state, whereas matching excitations is an open problem.

Q 4.7 Mo 15:30 E 214

Factorization with Gauss Sums — •Sabine Wölk and Wolfgang Schleich — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

Gauss sums manifest themeselves in many different physical phenomena. Therefore, the theoretical suggestion to factorize numbers with the help of the truncated Gauss sum led to many different realizations, such as the factorization with NMR, cold atoms, BEC, ultrashort laserpulses and classical light interferometry.

In the meantime, many questions such as "What happens, if we use rational numbers instead of integers as arguments of the truncated Gauss sum?" or "Is it possible to calculate Gauss sums efficient with the help of entanglement" turned up. In our talk, we will give a short overview of the topic of factorization with Gauss sums and try to answer sum of theses questions.

Q 4.8 Mo 15:45 E 214

Asymptotic dynamics of quantum systems under random unitary evolution — •Jaroslav Novotny[1,2], Gernot Alber[1], and Igor Jex[2] — [1]TU Darmstadt, Germany — [2]CTU in Prague, Czech Republic

We investigate the asymptotic dynamics of quantum systems resulting from large numbers of iterations of randomly applied unitary quantum operations. Despite the fact that in general the evolution superoperator of such random unitary operations cannot be diagonalized it is shown that the resulting iterated asymptotic dynamics is described by a diagonalizable superoperator. As a consequence it turns out that typically the resulting iterated asymptotic dynamics is governed by a low dimensional attractor space which is determined completely by the unitary transformations involved and which is independent of the probability distributions with which these unitary transformations are selected.

Based on this general approach analytical results are presented for the asymptotic dynamics of large qubit networks whose nodes are coupled by randomly applied controlled rotations.