Q 52 Quanteninformation III

Zeit: Dienstag 17:00–19:00 Raum: HU Audimax

Q 52.1 Di 17:00 HU Audimax

Complete hierarchies of efficient approximations to problems in entanglement theory — •Otfried Gühne[1], Jens Eisert[2], Philipp Hyllus[3], and Marcos Curty[4] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, A-6020 Innsbruck — [2]Institut für Physik, Universität Postdam, Am Neuen Palais 10, D-14469 Potsdam — [3]Institut für Theoretische Physik, Universität Hannover, Appelstraße 2, D-30167 Hannover — [4]Institut für Theoretische Physik I, Universität Erlangen-Nürnberg, Staudtstraße 7/B2, D-91058 Erlangen

In entanglement theory, many problems can be reduced to optimization problems. Examples of these problems are the decision whether a state is entangled or not and the minimization of expectation values of witnesses with respect to product states. In this contribution, we investigate this type of problems from the perspective of convex optimization. We show that these problems can be formulated as certain optimization problems: as optimization problems of a linear function with polynomial constraints on the variables, employing polynomials of degree three or less. We then apply known methods from the theory of semi-definite relaxations to these problems, notably a method due to Lasserre. By this we arrive at a hierarchy of efficiently solvable approximations to the solution, approximating the exact solution as closely as desired, in a way that is asymptotically complete. For example, this results in a hierarchy of sufficient criteria for entanglement, such that every entangled state will be detected in some step of the hierarchy. Finally, we present numerical examples to demonstrate the practical accessibility of this approach.

Q 52.2 Di 17:15 HU Audimax

Standard forms of noisy evolutions via depolarization — •Marc Hein[1], Wolfgang Dür[1], and Hans Jürgen Briegel[1,2] — [1]Institut für Theoretische Physik, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Österreich — [2]Institut für Quantenoptik und Quanteninformation der Österreichischen Akademie der Wissenschaften, Innsbruck, Österreich

We consider noisy, non-local unitary operations or interactions, i.e. the corresponding evolutions are described by completely positive maps or master equations of Lindbladt form. We show that by random local operations the maps or Liovillians can be depolarized to a standard form with a reduced number of parameters describing the noise process in such a way that the noiseless (Hamiltonian) part of the evolution is not altered. A further reduction of the parameters, in many cases even to a single one (i.e. global white noise), is possible by tailoring the evolutions and increasing the amount of noise. The resulting standard forms may be used to compute lower bounds on channel capacities and the lifetime of entangled states. Moreover these standard forms might be useful to derive error thresholds for entanglement purification and quantum computation which are valid for a more general class of noise processes.

Q 52.3 Di 17:30 HU Audimax

Integration of microoptics on atom chips — •Albrecht Haase[1], Marco Wilzbach[1], Michael Schwarz[1], Xiyuan Liu[2], Björn Hessmo[3], Peter Horak[4], and Jörg Schmiedmayer[1] — [1]Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg — [2]Lehrstuhl für Optoelektronik, Universität Mannheim, 69131 Mannheim — [3]Royal Institute of Technology, Dept. of Microelectronics and IT, S-16440 Kista, Sweden — [4]Optoelectronics Research Centre, University of Southampton, Southampton SO17 1BJ, UK

To develop the atom chip towards an universal tool for quantum information processing, we explore the possibility of integrating micro-optical components for the preparation, manipulation, and detection of atomic qubit states. As a first step, we are working on the implementation of an integrated single atom detector based on an optical fibre cavity. Recently, first fibre cavities have been realized and tested in our labs. We describe the setups and report on experimental parameters characterizing the quality and stability of these micro cavities. Furthermore, we present a test setup involving a macroscopic low-finesse cavity. By working close to the concentric cavity limit, the resonator mode is strongly focussed and thus the atom-light coupling strength is enhanced. This should make single atom resolution feasible. We show experimental results of magnetically guided atoms which have been detected using this cavity.

Q 52.4 Di 17:45 HU Audimax

Optimal entanglement and squeezing generation with noisy Gaussian channels — •Norbert Schuch, Michael M. Wolf, and J. Ignacio Cirac — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching

In quantum information processing with continuous variables, squeezing and entanglement are valuable resources which are hard to create, motivating the interest in efficient ways to generate them. Furthermore, channels creating these resources will in practice be noisy, i.e., non-unitary, making it even more demanding to create these quantities as quickly as possible.

We derive optimality results for the creation of both entanglement and squeezing with noisy Gaussian channels for various setups, where in general repeated applications of the channel are allowed and the channel is assisted by a set of additional operations which do not affect the resource. First, we consider the creation of squeezing with noisy maps supported by perfect passive transformations and explicitly derive optimal strategies. Second, we discuss the generation of entanglement between two Gaussian modes in two different scenarios: in one case, the set of available operations supplementing the channel is restricted to local passive operations, whereas in the second scenario all Gaussian local operations are permitted. We derive various results concerning the optimal creation of entanglement for both scenarios, and we also discuss the fundamental differences between both settings.

Q 52.5 Di 18:00 HU Audimax

Entanglement, Entropy, and Area — •Julian Dreissig[1], Marcus Cramer[1], Martin B. Plenio[2], and Jens Eisert[1,2] — [1]Institut für Physik, Universität Potsdam, Am Neuen Palais 10, D-14469 Potsdam — [2]Blackett Laboratory, Imperial College London, Prince Consort Road, SW7 2BW London

Starting from the question of the relation between entanglement, entropy, and area for harmonic lattice Hamiltonians we derive a strict relationship between the surface area of a distinguished hypercube and the degree of entanglement between this region and the rest of the lattice, in arbitrary dimensions [1]. Whereas for pure states the von Neumann entropy is used to characterize the degree of entanglement, we show that similar bounds can be found for mixed thermal states and corresponding operational entanglement measures as the distillable entanglement. Our analysis applied to systems with next-neighbor interactions can be extended to the limit of a free real Klein-Gordon field. We furthermore consider more general interaction types and systems with criticalities, including finite-size effects. We also show that these techniques for describing quantum systems can be used to establish a similar area-dependence for classical systems.

[1] M. B. Plenio, J. Eisert, J. Dreissig, and M. Cramer, submitted to Phys. Rev. Lett., quant-ph/0405142.

Q 52.6 Di 18:15 HU Audimax

Entanglement in spin chains and lattices with long-range interactions — •Lorenz Hartmann[1], Wolfgang Dür[1], Marc Hein[1], Hans Briegel[1,2], and Maciej Lewenstein[3] — [1]Institut für Theoretische Physik, Universität Innsbruck, Technikerstraße 25, 6020 Innsbruck, Österreich — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck, Österreich — [3]Institut für Theoretische Physik, Universität Hannover, Appelstraße 2, 30167 Hannover, Deutschland

We investigate entanglement properties of N initially disentangled spins, embedded in a ring or d-dimensional lattice. The spins interact via some long-range Ising-type interaction. A description in terms of generalized valence bond solids allows us, for arbitrarily large N, to efficiently calculate reduced density operators of up to ten particles. From these density operators we can compute many quantities, for example the bipartite entanglement S_L between a block of L neighboring spins and the remaining system, lower and upper bounds on the localizable entanglement, and higher order correlation functions. We vary the distance dependence of the interaction and investigate how this variation affects the scaling of the entropy S_L as L grows. We provide a sufficient condition when S_L saturates. In other cases, we find that the entanglement length diverges. For special configurations, we determine S_L analytically for all L in the limit N to infinity.

Q 52.7 Di 18:30 HU Audimax

Manipulation of Nuclear Spins in Single Electron Quantum Dots — •Henning Christ[1], Belen Paredes[1], Geza Giedke[2], Jacob Taylor[3], Peter Zoller[4], Micha Lukin [3], Atac Imamoglu[2], and Ignacio Cirac[1] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Institut für Quantenelektronik, ETH Zürich, Switzerland — [3]Department of Physics, Harvard University, USA — [4]Institut für Theoretische Physik, Universität Innsbruck, Austria

The long coherence times of nuclear spins have lead to various proposals for quantum information processing incorporating them. Thus it is desirable to have control over nuclear spins. We propose a new way of manipulating the collective state of a mesoscopic nuclear ensemble via the hyperfine interaction in a single electron quantum dot. It is demonstrated that the excitations created by a hyperfine-mediated flip-flop-process with the electron have bosonic character. We show that the dynamics is governed by a Jaynes-Cummings-like Hamiltonian which has been studied in quantum optics for decades and served as the theoretical basis for many spectacular experiments. Conditions for the validity of the bosonic approximation are derived and we specify the corrections to it. Noting the success of the transfer of this model to the area of superconducting devices, we illustrate the power of our approach for quantum dots by considering a novel proposal for quantum information processing and demonstrating squeezing of the collective nuclear spin state.

Q 52.8 Di 18:45 HU Audimax

Magnetisches Doppelmuldenpotential auf einem Atomchip — •Philipp Treutlein[1], Michael Ingrisch[1], Benjamin Lev[2], Tilo Steinmetz[1], Theodor W. Hänsch[1] und Jakob Reichel[1,3] — [1]Max-Planck-Institut für Quantenoptik und Sektion Physik der Ludwig-Maximilians-Universität München, Germany — [2]Norman Bridge Laboratory of Physics, California Institute of Technology, Pasadena, U.S.A. — [3]Laboratoire Kastler Brossel de l'ENS, Paris, France

Wir präsentieren den aktuellen Stand unseres Experiments mit Atomen in einem magnetischen Doppelmuldenpotential auf einem Mikrochip. Das magnetische Doppelmuldenpotential ist ein elementarer Baustein für die Quanteninformationsverarbeitung mit neutralen Atomen, für interferometrische Präzisionsmessungen und für die Untersuchung von Dekohärenzmechanismen. Auf einem Atomchip läßt sich ein solches Potential mit variabler Barrierenhöhe und variablem Abstand zwischen den Potentialmulden erzeugen. Ein Bose-Einstein-Kondensat im Doppelmuldenpotential kann durch Änderung der Barrierenhöhe aufgespalten und wieder vereinigt werden. Die Beobachtung von Interferenz zwischen den beiden Teilen des Kondensats ermöglicht Rückschlüsse auf die Eignung dieses Systems als miniaturisiertes Interferometer mit gefangenen Atomen. Ebenso kann quantenmechanisches Tunneln von Atomen durch die Potentialbarriere untersucht werden.