Q 14: Quanteninformation (Quantencomputer I)

Zeit: Dienstag 14:00–15:45 Raum: 1B

Gruppenbericht Q 14.1 Di 14:00 1B

Simulation of a Quantum Magnet — •Axel Friedenauer[1], Hektor Schmitz[1], Jan Glueckert[1], Lutz Petersen[2], and Tobias Schaetz[1] — [1]Max Planck Institut für Quantenoptik, Garching, Deutschland — [2]ETH Zuerich

Simulating quantum mechanical systems is a hard task since the amount of degrees of freedom scale exponentially with the number of constituents. We are aiming to circumvent this difficulty by introducing a quantum simulator based on the idea that systems governed by the same Hamiltonian evolve alike.

Our system for a feasibility study is a linear chain of magnesium ions. External fields and interactions between the ions are simulated/controled via rf- and laser-fields respectively. To initialize our system, we cool up to three ions close to the axial-motional ground state $\bar{n} < 0.05$.To calibrate our operational fidelities, we implemented a geometric phase gate[1] and prepared an entangled Bell state of two ions with a fidelity exceeding 95%. Subsequently, we were able to simulate an adiabatic evolution of two spins described by the Quantum-Ising-Hamiltonian from paramagentic into ferromagnetic order[2,3] with an fidelity of 95%. We proof that this transition is driven by quantum (not thermal) fluctuations providing us even an entangled state with a lower bound for the fidelity of 70%. We discuss these results and comment on the possibilities to increase the size of our system.

[1] D. Leibfried et al., Nature **422**, 412 (2003)

[2] D. Porras and J.I. Cirac, Phys. Rev. Lett. **92**, 207901 (2004)

[3] to be published

Q 14.2 Di 14:30 1B

Effects of imperfections for Shor's factorization algorithm — •Ignacio Garcia-Mata, Klaus M. Frahm, and Dima L. Shepelyansky — Laboratoire de Physique Theorique, UMR 5152 du CNRS, Universite Toulouse III

We study effects of imperfections induced by residual couplings between qubits on the accuracy of Shor's algorithm using numerical simulations of realistic quantum computations with up to 30 qubits. The factoring of numbers up to $N = 943$ show that the width of peaks, which frequencies allow to determine the factors, grow exponentially with the number of qubits. However, the algorithm remains operational up to a critical coupling strength ϵ_c which drops only polynomially with $\log_2 N$. The numerical dependence of ϵ_c on $\log_2 N$ is explained by analytical estimates that allows to obtain the scaling for functionality of Shor's algorithm on realistic quantum computers with a large number of qubits.

Q 14.3 Di 14:45 1B

Quantum Simulator for the Ising model with electrons floating on helium film — •Sarah Mostame and Ralf Schützhold — Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

We propose a physical setup that can be used to simulate the quantum dynamics of the Ising model. Our scheme consists of electrons floating on liquid helium which interact via Coulomb forces. In the limit of low temperatures (0.1 kelvin) the system will stay near the ground state where its Hamiltonian is equivalent to the Ising model. Furthermore, the proposed design is relevant to study the adiabatic quantum computers.

Q 14.4 Di 15:00 1B

Quantum Computation with Gaussian Continuous-Variable Cluster States — •Peter van Loock — Optical Quantum Information Theory Group, Max Planck Research Group, Institute of Optics, Information and Photonics, Staudtstr. 7/B2, 91058 Erlangen, Germany

We describe an extension of the cluster-state model for universal quantum computation from qubits to quantized harmonic oscillators, i.e., a translation from discrete to continuous quantum variables [1]. Compared to the discrete case, many features of the continuous-variable model have their direct analogues: cluster-state preparation via Gaussian (Clifford) operations, realization of any Gaussian transformation via Gaussian measurements in arbitrary order (Clifford computation and parallelism), and universal quantum computation via at least one non-Gaussian (non-Clifford) measurement including feedforward. For the optical creation of approximate cluster states in form of multi-mode squeezed Gaussian states [2] and the optical implementation of small-scale cluster computations [3], we discuss various protocols including linear-optics generation schemes and protocols for finite-squeezing-induced error filtration.

[1] N. C. Menicucci, P. van Loock, M. Gu, C. Weedbrook, T. C. Ralph, and M. A. Nielsen, Phys. Rev. Lett. **97**, 110501 (2006).

[2] P. van Loock, C. Weedbrook, and M. Gu, Phys. Rev. A **76**, 032321 (2007).

[3] P. van Loock, J. Opt. Soc. Am. B **24**, 340 (2007).

Q 14.5 Di 15:15 1B

Pseudo bound entanglement in NMR quantum computing — •Hermann Kampermann[1], Xinhua Peng[2], Dagmar Bruss[1], and Dieter Suter[2] — [1]Theoretische Physik III, Universität Düsseldorf — [2]Experimentelle Physik IIIa, Universität Dortmund

In NMR we have precise coherent control of small qubit systems (up to roughly 12 qubits), but NMR systems used today consist of large ensembles of nuclear spin quantum processors in a higly mixed (separable) state. So-called pseudo pure states are used to circumvent this problem. We use liquid state Nuclear Magnetic Resonance (NMR) to generate a 3-qubit "pseudo bound entangled state"and characterize it via state tomography and by detection of a witness operator for this class of states.

Q 14.6 Di 15:30 1B

A Quantum CISC Compiler and Scalable Assembler for Quantum Computing on Large Systems — •Thomas Schulte-Herbrüggen, Andreas Spörl, and Steffen Glaser — Dept. Chemistry, Technical University of Munich (TUM), 85747 Garching

Using the cutting edge high-speed parallel cluster HLRB-II (with a total LINPACK performance of 63.3 TFlops/s) we present a quantum CISC compiler into time-optimised or decoherence-protected complex instruction sets. They comprise effective multi-qubit interactions with up to 10 qubits. We show how to assemble these medium-sized CISC-modules in a scalable way for quantum computation on large systems. Extending the toolbox of universal gates by optimised complex multi-qubit instruction sets paves the way to fight decoherence in realistic Markovian and non-Markovian settings.

The advantage of quantum CISC compilation over standard RISC compilations into one- and two-qubit universal gates is demonstrated *inter alia* for the quantum Fourier transform (QFT) and for multiply-controlled NOT gates. The speed-up is up to factor of six thus giving significantly better performance under decoherence. – Implications for upper limits to time complexities are also derived.