Q 77 Poster Quantencomputer

Zeit: Donnerstag 16:30–18:30 Raum: Labsaal

Q 77.1 Do 16:30 Labsaal

Classical Simulation of Quantum Algorithms — •Jörg Wassenberg and Gernot Alber — Institut für Angewandte Physik, Technische Universität Darmstadt, Hochschulstraße 4a, D-64289 Darmstadt

Quantum algorithms can be efficiently simulated on a classical computer if the entanglement scales at most logarithmically with the size of the system. Unfortunately most known quantum algorithms do not fulfill this requirement. However, imperfections such as couplings between qubits might lead to a reduction of entanglement and allow an efficient classical simulation. In our work we study the effect of different error types in various quantum algorithms.

Q 77.2 Do 16:30 Labsaal

Decoupling quantum dynamics in a detected-jump correcting code — •Daniel Geberth and Gernot Alber — Institut für Angewandte Physik, TU Darmstadt, 64289 Darmstadt

The dominating goal in practical quantum information is attaining the highest possible fidelity over long times of computation or storage. A concatenated error correction method consisting of an error correcting code to address spontaneous emission and a decoupling scheme to weaken the effects of coherent couplings are presented. Limitations on the choice and strength of the decoupling operators and the resulting attainable fidelity decay rates are discussed.

Q 77.3 Do 16:30 Labsaal

Eine segmentierte Falle für Kalzium-Ionen — •Thomas Deuschle, Robert Maiwald, Johannes Eble, Gerhard Huber, Kilian Singer und Ferdinand Schmidt-Kaler — Universität Ulm, Abt. Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, 89069 Ulm

Wir stellen eine segmentierte, lineare Paulfalle für die Quanteninformationsverarbeitung mit $^{40}Ca^{+}$-Ionen vor. Die Falle ist aus goldbeschichteten Aluminiumoxidwafern aufgebaut, die mittels Laserablation strukturiert wurden. Die typische Dimension einzelner Fallensegmente liegt im Bereich von $100\mu m$. Durch Veränderung der Spannungen an den Segmenten ist es möglich, Ionen in maßgeschneiderten Fallenpotenzialen zu speichern und durch Verschiebung der Potentialminima zu transportieren. Berichtet wird über den aktuellen Stand der Experimente an dieser Mikrofalle.

Q 77.4 Do 16:30 Labsaal

Holonomic quantum computation with ions and neutral atoms — •Jordi Tiana Alsina and Wolfgang Schleich — Abteilung Quantenphysik, Universität Ulm, 89069 Ulm

We want to show that it is possible to obtain an universal quantum computer using only geometric manipulations. To achive this we use quantum gates solely based on abelian and non-abelian geometric operations (holonomies). We show that we can implement single and two qubits gates using neutral atoms in a cavity QED or ions in an ion-trap. Finally we analize the possibilty to do holonomic quantum computation based on neutral atoms in an optical lattice.

Q 77.5 Do 16:30 Labsaal

Quantenprozesstomografie als Werkzeug zur Diagnose eines Ionenfallen-Quantencomputers — •Mark Riebe[1], C. Roos[1,2], M. Chwalla[1], D. Chek-al-kar[1], K. Kim[1], H. Häffner[1,2], W. Hänsel[1], P. Schmidt[1] und R. Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck — [2]Institut für Quantenoptik und Quanteninformation der Österreichischen Akademie der Wissenschaften, Technikerstraße 21a, A-6020 Innsbruck

Quantenprozesstomografie erlaubt die vollständige Charakterisierung der an einem Quantensystem durchgeführten Operationen. In unseren Experimenten werden in einer Ionenfalle gespeicherte Ketten von $^{40}Ca^{+}$-Ionen verwendet, um Quanteninformation zu speichern und zu verarbeiten. In diesem System wurden bereits die für einen Quantencomputer grundlegenden Operationen, wie Einzelqubit-Rotationen und Quantengatter zwischen zwei Ionenqubits, demonstriert und zur Realisierung einiger einfacher Quantenalgorithmen verwendet. Ein zentraler Baustein ist dabei die CNOT-Gatteroperation [1]. Dieser Baustein wurde mittels Prozesstomografie vollständig charakterisiert. Dadurch wurde es möglich die Wirkungsweise des Gatters in Hinblick auf dessen Fähigkeit zur Verschränkung von Qubits zu untersuchen. Ferner wurde untersucht inwieweit der Zustand des Qubitregisters nach Anwendung des Quantengatters aufgrund von experimentellen Imperfektionen gemischt ist.

[1] F. Schmidt-Kaler, H. Häffner, M. Riebe, S. Gulde, G. P. T. Lancaster, T. Deuschle, C. Becher, C. F. Roos, J. Eschner and R. Blatt, Nature 422, 408 (2003): Realization of the Cirac-Zoller controlled-NOT quantum gate

Q 77.6 Do 16:30 Labsaal

Segmented Ion Traps for Quantum Computation — •Felicity Splatt[1], Wolfgang Hänsel[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Technikerstr. 25, A-6020 Innsbruck — [2]Institut für Quantenoptik und Quanteninformation, Technikerstr. 21a, A-6020 Innsbruck

Linear ion trap quantum computing, in which qubits are formed from the electronic states of trapped ions and are coupled through the Coulomb interaction, has already achieved considerable success. A promising route to scale up the number of qubits in such traps is the use of segmented traps that are formed by elecrodes on a microchip. We have developed several chip layouts that are about to be tested in a new vacuum setup. This poster describes our progress on this work.

Q 77.7 Do 16:30 Labsaal

Stabilizing decoupling and recoupling schemes by randomization — •Oliver Kern and Gernot Alber — Institut für Angewandte Physik, Hochschulstrasse 4a, 64289 Darmstadt, Germany

In quantum information processing the presence of residual static interqubit couplings leads to a rapid Gaussian decay of the fidelity. By applying randomly chosen Pauli matrices to the qubits at times $j \cdot \Delta t$ ($j \in \mathbf{N}$) this fidelity decay was shown to be reducible to a linear-in-time exponential one [1]. In fact it was shown in [2] that with this method the error is certainly smaller than $\mathcal{O}(\Delta t \cdot T \cdot k^2)$ where k is the largest eigenvalue of the Hamiltonian describing the couplings. Using instead a deterministic decoupling sequence, applied periodically over multiples of the sequence time T_c, the error can be guaranteed to be smaller than $\mathcal{O}(T^2 \cdot k^4 \cdot T_c^2)$. We present a method which combines the advantages of both methods and show that we can guarantee that the error will be smaller than $\mathcal{O}(T \cdot T_c^3 \cdot k^4)$, i.e. linear in time and fourth order in k.

On the other hand inter-qubit couplings are commonly used to generate two qubit gates in NMR quantum computation. We show how the recently introduced selective recoupling scheme of Yamaguchi et al. [3] can be stabilized by suited randomization against the accumulation of residual higher order average Hamiltonian theory errors.

[1] O. Kern, G. Alber, and D. L. Shepelyansky, Eur. Phys. J. D **32**, 153 (2005)
[2] L. Viola and E. Knill, Phys. Rev. Lett. **94**, 060502 (2005)
[3] F. Yamaguchi, T. D. Ladd, C. P. Master, Y. Yamamoto, and N. Khaneja, quant-ph/0411099.

Q 77.8 Do 16:30 Labsaal

The Quantum Fourier Transform in a molecular vibrational qubit system — •Ulrike Troppmann, Caroline Gollub, and Regina de Vivie-Riedle — Ludwig-Maximilians-Universität, Department Chemie, Butenandtstr. 11, 81377 München

In our proposal of molecular quantum computing, we have suggested to use vibrational eigenstates of a molecule to encode the qubit states. Merging the ideas of coherent control and quantum computation, specially shaped ultrashort laser pulses, caculated with a multi target optimal control algorithm, induce the global quantum gates [1]. We discuss aspects of phase control and phase development in such multi qubit systems and suggest that, as an alternative to direct laser control, any phase rotation gate can be implemented by free evolution of the system during a defined delay between qubit flip pulses [2]. This new approach introduces a great flexibility to our concept of molecular quantum computing, with regard to the basis set independence of single quantum gates and the robust implementation of quantum algorithms. We demonstrate this with the realization of the Quantum Fourier Transform in a model vibrational qubit system.

[1] C. M. Tesch, R. de Vivie-Riedle, *Phys. Rev. Lett.*, **89**, (2002), 157901.
[2] U. Troppmann, C. Gollub, R. de Vivie-Riedle, submitted to *N. J. Phys.*

Q 77.9 Do 16:30 Labsaal

The Quantum Random Walk to be Implemented in an Ion Trap — •Axel Friedenauer, Hector Schmitz, Steffen Kahra, and Tobias Schätz — Max-Planck-Institut für Quantenoptik, Hans-Kopfermannstr. 1, 85748 Garching

Many classical search algorithms implement random walks. Possible future quantum algorithms could provide a considerable speed up by using quantum random walks. We follow a proposal by Travaglione and Milburn[1]. We intend to use hyperfine structure levels of a single $^{25}Mg^{+}$ ion in a Paul trap as states of a qubit. Applying a $\frac{\pi}{2}$ pulse we can create a coherent superposition of states which corresponds to tossing a quantum coin. The following conditional step to the left or right can be realized by a state dependent force encoding the direction of the step into the vibrational mode of the ion and repeat this procedure n times. Afterwards we can read out the vibrational excitation of the ion. Beginning with the 3rd step one should see a discrepancy to the classical counterpart. Future perspectives could include using several ions and entanglement.

[1] B.C. Travaglione and G.J. Milburn, Phys. Rev. A **65**, 3, 032310 (2002)