Q 21: Quanteninformation (Quantencomputer II)

Zeit: Dienstag 16:30–17:30 Raum: 1B

Q 21.1 Di 16:30 1B

Towards two-dimensional quantum simulations with trapped ions — •Christian Schneider, Robert Matjeschk, and Tobias Schätz — Max-Planck-Institut für Quantenoptik

An ion crystal in a Paul trap is a promising candidate for a quantum simulator or analogue quantum computer. Thereby a quantum system shall be implemented and studied which is described by the same Hamiltonian as the system to be simulated. The crucial parameters of the implemented system are accessible which is often not the case for the "real" sytem. First experimental results in building a quantum simulator for a quantum spin Ising Hamiltonian with two ions have recently been shown [1].

To gain deeper insight into quantum dynamics, we plan to extend these fundamental experiments to more ions and into two dimensions [2]. As successful studies of one-dimensional planar Paul traps have been shown [3,4], a promising approach is to realize a two-dimensional array of trapped ions in a planar two-dimensional surface trap. We want to show our visions of two-dimensional quantum simulations and first steps towards their realization by a two-dimensional Paul trap of 2×2 ions.

[1] Phys. Rev. Lett., to be submitted
[2] T. Schätz et. al., J. Mod. Opt., accepted
[3] J. Chiaverini et. al., Quant. Inf. Comp. 5, 419–439
[4] S. Seidelin et. al., Phys. Rev. Lett. 96, 253003–4

Q 21.2 Di 16:45 1B

Coherent Transport of Atoms in Arrays of Dipole Traps — •Jens Kruse, Andre Lengwenus, Malte Schlosser, Christian Gierl, Joost Sattler, and Gerhard Birkl — Institut für Angewandte Physik, TU Darmstadt, Schlossgartenstr. 7, 64289 Darmstadt

For the experimental realization of quantum information processing it is essential to perform one- and two-qubit operations in a controlled fashion. In our approach, qubits are inscribed in the hyperfine states of rubidium atoms. The atoms are trapped in a two-dimensional array of well separated optical micro-potentials created by micro-fabricated lens arrays. We already demonstrated single-qubit operations by the coherent coupling of the hyperfine ground states of ^{85}Rb by stimulated Raman transitions.

We plan the realization of two-qubit gates by the use of ultracold collisions. For this, atoms have to be transported from one trap position to another. We demonstrate the transfer of atoms in microtraps using steering methods which are based on the variation of the incident angle of the laser beam illuminating the array of microlenses. By using Ramsey and spin-echo methods we study the effects of transport on the coherence of the system. We observed that the transfer of atoms over a distance of up to the full trap separation does not cause any additional loss of coherence.

Q 21.3 Di 17:00 1B

Grundzustandskühlung und Qubit-Manipulation in einer segmentierten Mikroionenfalle — •Stephan Schulz, Ulrich Poschinger, Frank Ziesel und Ferdinand Schmidt-Kaler — Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, 89069 Ulm

Mikrostrukturierte segmentierte lineare Paulfallen zur Speicherung und Manipulation von Qubit-Systemen mittels Ionenkristallen sind ein aussichtsreicher Ansatz auf dem Weg zum skalierbaren Quantencomputer.

Wir zeigen experimentelle Ergebnisse für eine lineare segmentierte Mikroionenfalle mit $^{40}Ca^{+}$-Ionen. Die insgesamt 31 Segmentpaare sind mit 62 verschiedenen elektrischen Spannungen ansteuerbar und in einen Speicher- (9 Segmentpaare), Transfer- (3) und Prozessorbereich (19) unterteilt. Die Breite der Segmentpaare beträgt 250μm bzw. 100μm. Es werden radiale und axiale Fallenfrequenzen im MHz-Bereich gemessen.

Die gefangenen Ionen werden nach Dopplerkühlen auf dem $S_{1/2} \leftrightarrow P_{1/2}$-Übergang durch Fluoreszenz auf diesem Übergang nachgewiesen. Mittels Seitenbandspektroskopie auf dem $S_{1/2} \leftrightarrow D_{5/2}$-Übergang wird die Mikroionenfalle charakterisiert und die Mikrobewegung kompensiert. Der Quadrupolübergang erlaubt die kohärente Qubit-Manipulation. Wir berichten von Grundzustandskühlen und Rabioszillationen in der Mikrofalle.

Q 21.4 Di 17:15 1B

New universal resource states — •David Gross and Jens Eisert — Institute for Mathematical Sciences, Imperial College London, 53 Prince's Gate, London SW7 2PG, UK

Based on a previously established framework [1], we present new examples of universal resource states for measurement-based quantum computation. In particular, we discuss the concept of "quantum wires". These are quantum states on a one-dimensional string, which can be used to transport and process quantum information solely by means of local measurements. In a certain parameter regime, quantum wires can be completely parameterized and their properties explicitly computed. States of these kind may be thought of as primitives for the construction of two-dimensional resources states, universal for quantum computing. We discuss means of coupling such one-dimensional wires to form universal resources.

[1] D. Gross and J. Eisert, Phys. Rev. Lett. 98, 220503 (2007); D. Gross, J. Eisert, N. Schuch, and D. Perez-Garcia, Phys. Rev. A 76, 052315 (2007).