Q 24: Quantum information: Atoms and ions II

Time: Tuesday 11:00–12:30 Location: A 310

Group Report Q 24.1 Tue 11:00 A 310

Trajectory-Based Micro-Motion Compensation and Simulation of Long Distance Entanglement in a Segmented Trap

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We report on the minimization of micromotion in a segmented linear paul trap by analyzing equilibrium position trajectories under dc and rf variations. We discuss the modelling and analysis of such trajectories and introduce methods to speed up the local optimization process down to a few seconds. We give an estimate for the accuracy of the optimization procedure and compare to other methods.

Furthermore, we propose an experiment to demonstrate the presence of long distance entanglement (LDE) in such a trap. LDE refers to the occurrence of ground-state entanglement between the end spins of a spin chain, and can be used to implement a quantum bus [1]. By designing the axial trapping potential, the required relative coupling strengths can be realized; suitable XY interactions can be obtained using a sequence of microwave pulses. We discuss how to combine this with previous findings for the adiabatic preparation of the ground state of an XY spin chain which exhibits LDE, and we demonstrate numerically its feasibility with realistic parameters.

[1] S. M. Giampaolo, F. Illuminati, New J. Phys. 12, 025019 (2010)

Q 24.2 Tue 11:30 A 310

Effects of ion motion in photon-assisted entanglement creation

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We investigate ion motion as a source of decoherence in the implementation of a hybrid quantum repeater. Studying the dynamics of ion motion in the Lamb-Dicke regime we explore possibilities of entangling two distant material qubits, realized by the internal states of two ions, which interact resonantly with single-mode cavity fields. For the purpose of achieving entangled pairs with high fidelity and with high probability we use an optimal generalized field measurement which is capable of preparing entangled states by postselection. We show that the quality of the entanglement depends primarily on the trap frequency. High trap frequencies enhance the fidelity of the postselected entangled pairs. We also propose a set of dynamical decoupling schemes performed locally on the ions which can suppress ion motion induced decoherence independently from other decoherence sources.

Q 24.3 Tue 11:45 A 310

Operating 2D Arrays of Addressable Ion Traps

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Controlling interactions between ions in a one dimensional array of ion traps, via a segmented linear ion trap, is becoming standard technology. Extending these methods to two dimensions, however, is not trivial. The trapping and control of $^{40}Ca^{+}$ ions in a 4 by 4 array of addressable planar-electrode ion traps is shown. Demonstration of micromotion minimization and estimates of the heating rate of the ions will be given.

Q 24.4 Tue 12:00 A 310

Transport- und Gatteroperationen zur skalierbaren Quanteninformationsverarbeitung

— •Henning Kaufmann[1], Thomas Ruster[1], Andreas Walther[2], Max Hettrich[1], Kilian Singer[1], Ferdinand Schmidt-Kaler[1] und Ulrich Poschinger[1] — [1]QUANTUM, Institut für Physik, Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany — [2]Department of Physics, Lund University, Box 118, SE-221 00 Lund

Das Ziel unserer Experimente ist die Realisierung von Quantenrechnungen mit Hilfe gefangener Ionen in segmentierten Mikro-Ionenfallen. Wir stellen den Fortschritt der Realisierung schneller Transportoperationen über makroskopische Distanzen innerhalb einer Zeitskala nahe der Fallenperiode vor. Diese Transportoperationen konnten für ein einzelnes Ion realisiert werden, wobei die verbliebene Bewegungsenergie nach dem Transport mit einer Genauigkeit unter dem Einzel-Quantenniveau kontrolliert werden kann [1]. Wir konnten ausserdem zeigen, dass ein Zustand welcher in Spin- und Bewegungszustand verschränkt ist, die Transportoperation überdauert. Schritte zur Demonstration der Skalierbarkeit dieses Ansatzes beinhalten die numerischen Modellierung der Transportoperationen mit hinreichender Präzision. Diese konnte in der erfolgreichen Übereinstimmung von gemessenen Verschiebungsamplituden mit numerischen Resultaten gezeigt werden [2]. Wir berichten desweiteren von der Realisierung des geometrischen Phasengatters und der Entwicklung kontrollierter Teilungsoperationen.

[1] A. Walther et al. PRL **109**, 080501 (2012). [2] F. Ziesel et al., arxiv:1211.5490 , (2012). [3] D. Leibfried et al., Nature **422**, 412 (2003).

Q 24.5 Tue 12:15 A 310

Full solid angle imaging of a single ion

— •Martin Fischer[1,2], Robert Maiwald[1,2], Andrea Golla[1,2], Marianne Bader[1,2], Markus Sondermann[1,2], and Gerd Leuchs[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Erlangen, Germany

In most ion trapping experiments the geometry of the trap as well as application specific restrictions significantly reduce the solid angle under which the ion can be observed. In our setup we make use of an ion trap designed to minimize the obscured solid angle [1]. This trap is combined with a parabolic mirror covering 81 % of the solid angle providing us with a setup capable of imaging our single emitter with sub-wavelength resolution [2]. We report on the highest resolution in imaging a single atomic emitter. Furthermore our system shows high sensitivity to misalignment of the ion from the focus of the parabolic mirror making sub-wavelength displacements easily detectable.

[1] R. Maiwald *et al.*, Nature Physics **5**, 551 (2009)
[2] R. Maiwald *et al.*, Phys. Rev. A **86**, 043431 (2012).