Q 21: Quantum information: Atoms and ions III

Time: Tuesday 10:30–12:15 Location: UDL HS3038

Q 21.1 Tue 10:30 UDL HS3038

Technologies for Quantum Control of Trapped Ions — •Florian Leupold, Joseba Alonso, Ludwig de Clercq, Matteo Fadel, Benjamin Keitch, Daniel Kienzler, Hsiang-Yu Lo, Vlad Negnevitsky, and Jonathan Home — Institute for Quantum Electronics, ETH Zürich

Scaling up quantum control to large numbers of qubits and gates is one of the main challenges in trapped-ion quantum information, and information transport is a key ingredient. One promising method for transporting quantum information stored in the internal states of trapped ions is to transport the ions themselves by dynamically changing the trapping potential. The speed of this transport has thus far been limited by the update rates of the potentials applied to the trap electrodes.

We have recently proposed to place single pole, double throw switches close to the ion trap itself, enabling the trap potentials to be changed on timescales fast compared to the oscillation frequency of the ion [1]. This could allow transport of ions over macroscopic distances within half an axial oscillation cycle.

To test this method we have built a micro-fabricated a surface-electrode ion trap in an ultra-high vacuum system cooled to 4K by a liquid helium recondenser cryostat. In this setup the control potentials are switched by CMOS electronics at the 4K stage. We have extensively tested the electronics, and are now working on first demonstrations with trapped ions.

[1] Alonso, J. et al. New J. Phys. 15 (2013)

Q 21.2 Tue 10:45 UDL HS3038

Generation of non-classically correlated separable states with correlated dephasing — •Edoardo Carnio, Manuel Gessner, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

In trapped-ion experiments, a correlated dephasing effect is caused by fluctuations of the magnetic field. In our work we analyse the possibility to use this noise source for state engineering, and we use a geometric picture to explain the effect on the ions' spins. In particular, we investigate how correlated dephasing affects quantum correlations in separable states in terms of the correlation rank. Moreover, starting from a classically correlated state, we show that there is always an experimental configuration to generate separable states with maximal correlation rank.

Q 21.3 Tue 11:00 UDL HS3038

Stabilität von Defekten in Ionenkristallen und experimentelle Bestimmung des Peierls-Nabarro Potentials — •Stefan Ulm, Karin Groot-Berning, Johannes Rossnagel, Georg Jacob, Oscar Estrada, Ferdinand Schmidt-Kaler und Kilian Singer — QUANTUM, Inst. für Physik, Johannes Gutenberg Universität Mainz

Kürzlich gelang es den inhomogenen Kibble-Zurek Effekt in Ionenkristallen nachzuweisen [1]und die Vorhersagen [2] der Dichte von strukturellen Defekten beim Phasenübergang zu bestätigen. Da der experimentelle Nachweis von Defekten mittels Abbildung der Ionenfluoreszenz mehrere Millisekunden benötigt, spielt die Stabilität der strukturellen Defekte eine wichtige Rolle für die gemessene Erzeugungswahrscheinlichkeit. Wir ermitteln das Peierls-Nabarro Potential [3], welches für die Stabilität entscheidend ist, aus der Lebensdauer der Defekte indem wir die Fallenparameter variiern.

[1] S. Ulm, et al., Nat. Comm. 4, 2290 (2013), K. Pyka, et al., Nat. Commun. 4, 2291 (2013), und S. Ejtemaee and P. C. Haljan., Phys. Rev. A 87, 051401, (2013). [2] W. Zurek, J. Phys. Condens. Matter, 25(40):404209 (2013). [3] H. Landa, et al., New J. Phys. 15, 093003 (2013)

Q 21.4 Tue 11:15 UDL HS3038

Transport of ions prepared in superpositions of hyperfine states — •Michael Johanning, M. Tanveer Baig, Thomas Collath, Timm F. Gloger, Delia Kaufmann, Peter Kaufmann, and Christof Wunderlich — Faculty of Science and Technology, Department of Physics, University of Siegen, Walter Flex Str. 3, 57072 Siegen, Germany

We analyze the coherence of hyperfine states during adiabatic shuttling of Yb-ions and discuss the calculation of proper shuttling potentials based on electric field simulations in our trap. Shuttling is carried out with a success rate indistinguishable from unity and this figure of merit is limited by ions becoming dark. The coherence of superpositions of hyperfine states is experimentally characterized by bracketing a variable number of shuttling attempts by $\pi/2$-pulses effectively forming a Ramsey sequence with a fixed free precession time. The results are analysed in terms of a reduction of Ramsey fringe contrast: we observe a state infidelity of about 1 % per shuttling when shuttling over a distance of 100 μm and discuss strategies to further improve on this result.

Q 21.5 Tue 11:30 UDL HS3038

Dynamics of topological defects in ion Coulomb crystals — •Tobias Burgermeister[1], Heather L. Partner[1], Ramil Nigmatullin[2,3], Karsten Pyka[1], Jonas Keller[1], Alex Retzker[4], Martin B. Plenio[2,3], and Tanja E. Mehlstäubler[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Institut für Theoretische Physik, Universität Ulm, Germany — [3]Department of Physics, Imperial College London, UK — [4]Racah Institute of Physics, The Hebrew University of Jerusalem, Israel

We report on our recent experimental and theoretical studies of structural defects (kink solitons) in ion Coulomb crystals [1]. We show how two different types of kinks can be produced by non-adiabatically quenching of the radial trapping potential. Calculations of the Peierls-Nabarro potentials are presented for both kink types to explain kink properties observed in the experiment and in simulations. In addition, we discuss the influence of mass defects on kinks. This influence can be modified in a controlled way by an additionally applied electric field. Finally we present experimental methods for a deterministic creation and manipulation of kink defects.

[1] Partner *et al.*, *New J. Phys.* **15**, 103013 (2013)

Q 21.6 Tue 11:45 UDL HS3038

Quantum state generation by reservoir engineering of trapped-ions — •Daniel Kienzler, Hsiang-Yu Lo, Benjamin C. Keitch, Christa Flühmann, Ludwig E. de Clercq, Florian Leupold, Frieder Lindenfelser, Vlad Negnevitsky, Joseba Alonso, and Jonathan P. Home — Institut für Quantenelektronik, Eidgenössische Technische Hochschule Zürich, Schweiz

Coupling of quantum systems to an engineered reservoir provides new opportunities for quantum state generation and open-systems quantum engineering. We have recently demonstrated a new form of reservoir engineering following the proposal of [1], allowing us to generate superposition states of trapped-ion motion as the dark state of the engineered dissipation process. I will describe this work, and in addition quantum control of calcium ion optical-qubits in our micro-structured segmented linear Paul trap.

[1] J. F. Poyatos, J. I. Cirac, P. Zoller Quantum Reservoir Engineering with Laser Cooled Trapped Ions, Phys. Rev. Lett. 77 004728, (1996)

Q 21.7 Tue 12:00 UDL HS3038

Eine Einzel-Ionen-Wärmekraftmaschine mit Wirkungsgrad über dem klassischen Carnot-Limit — •Johannes Rossnagel[1], Nicolas Tolazzi[1], Obinna Abah[2], Ferdinand Schmidt-Kaler[1], Kilian Singer[1] und Eric Lutz[2] — [1]QUANTUM, Institut für Physik, Universtität Mainz, Staudingerweg 7, 55128 Mainz — [2]Department für Physik, Universität Erlangen-Nürnberg, 91058 Erlangen

Wir präsentieren einen Vorschlag für eine Wärmekraftmaschine, deren Arbeitsmedium aus einem einzelnen, gefangenen Ion besteht. Hierfür wird eine Paul-Falle mit Trichterförmiger Geometrie verwendet, die eine Umsetzung ungerichteter thermischer Bewegung in eine kohärente Schwingung erlaubt. Durch die Kopplung des Ions an zwei Wärmebäder bei unterschiedlichen Temperaturen durchläuft das System einen Otto-Kreisprozess. Eine solche Nano-Wärmekraftmaschine kann über einen weiten Bereich von Temperdifferenzen der Bäder bei maximal möglicher Ausgangsleistung betrieben werden [1]. Wir zeigen, dass der Wirkungsgrad bei maximaler Leistung der Maschine über die klassische Carnot-Grenze erhöht werden kann, wenn man eines der Wärmebäder durch ein nicht-klassisches, gequetschtes Bad ersetzt [2]. Wir präsentieren ausführliche Monte-Carlo Simulationen zu diesem System, sowie erste Schritte zur experimentellen Realisierung.

[1] O.Abah, J.Roßnagel, G.Jacob et al., PRL 109, 203006 (2012).

[2] J.Roßnagel, O.Abah, F.Schmidt-Kaler et al., arXiv:1308.5935 (2013) (submitted).