Q 58: Quanteninformation: Atome und Ionen III

Zeit: Freitag 10:30–12:00 Raum: VMP 6 HS-A

Q 58.1 Fr 10:30 VMP 6 HS-A

a millisecond quantum memory for scalable quantum networks — •Bo Zhao[1], Yuao Chen[1,2], Xiaohun Bao[1,2], Thorsten Strassel[1], Chihsung Chuu[1], Xianmin Jin[2], Jörg Schmiedmayer[3], Zhensheng Yuan[1,2], Shuai Chen[1], and Jianwei Pan[1,2] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Hefei National Laboratory for Physical Sciences at Microscale and Department of Modern Physics, University of Science and Technology of China Hefei, Anhui 230026, China — [3]Atominstitut derösterreichischen Universitäten, TU-Wien, A-1020 Vienna Austria

Scalable quantum information processing critically depends on the capability of storage of a quantum state. Although atomic memories for classical lights and continuous variables have been demonstrated with milliseconds storage time, there is no equal advance in the development of quantum memory for single excitations, where only around 10 μs storage time was achieved. Here we report our experimental investigations on extending the storage time of quantum memory for single excitations. We isolate and identify distinct mechanisms for the decoherence of spin wave in atomic ensemble quantum memories. By exploiting the magnetic field insensitive state, "clock state", and generating a long-wavelength spin wave to suppress the dephasing, we succeed in extending the storage time of the quantum memory to 1 ms. Our result represents a substantial progress towards long-distance quantum communication and enables a realistic avenue for large scale quantum information processing.

Q 58.2 Fr 10:45 VMP 6 HS-A

Detection and engineering of spatial entanglement with ultracold bosons — John Goold[1], Libby Heany[2], •Thomas Busch[1], and Vlatko Vedral[2,3] — [1]Physics Department, University College Cork, Cork, Ireland — [2]Centre for Quantum Technologies, National University of Singapore, Singapore — [3]School of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT, UK

Natural entanglement between spatial modes is known to exist in samples of cold atomic gases as a consequence of spatial coherence. To detect this kind of entanglement an interferometric scheme can be used, which at the same time also quantification of any bi-modal or multimodal setup.

We will outline the interferometric scheme and show that it can straightforwardly be applied to interacting Bose gases of fixed particle number and even finite temperatures. Furthermore we will show that spatial entanglement can be described using the off-diagonal elements of a systems reduced single-particle density matrix.

When applying the scheme to the problem of an interacting, harmonically trapped boson pair in one dimension, we show that while entanglement rapidly decrease with temperature, one can always find modes for which a finite amount can be found. At zero temperature a significant amount of entanglement can be found for all interaction strengths and we will demonstrate how by changing the interaction parameter the distribution of entanglement between different spatial modes can be modified.

Q 58.3 Fr 11:00 VMP 6 HS-A

Test der Quanten-Jarzynski-Gleichung mit kalten Ionen in einer segmentierten Paul-Falle — •Gerhard Huber[1], Sebastian Deffner[2], Eric Lutz[2] und Ferdinand Schmidt-Kaler[1] — [1]Universität Ulm, Institut für Quanteninformationsverarbeitung, Albert-Einstein-Allee 11, D-89069 Ulm — [2]Department of Physics, University of Augsburg, D-86135 Augsburg

Wir stellen ein Schema vor [1], mit dem ein experimentell bisher noch nicht verifiziertes, bemerkenswertes Ergebnis aus der Quantenthermodynamik überprüft werden kann. Die Jarzynski-Gleichung [2] erlaubt es, Änderungen der freien Energie eines Systems unter beliebig schnellen Potentialänderungen [3] exakt zu berechnen. Der Bewegungszustand eines einzelnen kalten Ions in einer segmentierten Paul-Falle kann geeignet präpariert und sein Bewegungszustand mit solcher Präzision vermessen werden, dass es möglich ist, die zur Überprüfung der Jarzynski-Gleichung benötigte Arbeitsverteilung [4] zu rekonstruieren. Das geschieht mit einem „Phononen-Filter", der quantenoptisch mittels Laserpulsen realisiert wird und auf nichtdestruktiver Fluoreszenzdetektion beruht [1]. Unser Schema zeigt, dass gefangene Ionen ein ideales System für experimentelle Untersuchungen von Prozessen der Nichtgleichgewichts-Thermodynamik darstellen.

[1] G. Huber et al., Phys. Rev. Lett. **101**, 070403 (2008)
[2] C. Jarzynski, Phys. Rev. Lett. **78**, 2690 (1997)
[3] G. Huber et al., New J. Phys. **10**, 013004 (2008)
[4] S. Deffner and E. Lutz, Phys. Rev. E **77** 021128 (2008)

Q 58.4 Fr 11:15 VMP 6 HS-A

Simulation of an Acoustic Black Holes on an Ion Ring — •Birger Horstmann[1], Benni Reznik[2], Diego Porras[1], and Ignacio Cirac[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany — [2]Department of Physics and Astronomy, Tel Aviv University, Ramat Aviv 69978, Israel

In this talk we present results on the simulation of acoustic black holes on an ion ring. Ion rings, which have already been realized experimentally, represent ion chains with periodic boundary conditions. If the ions are rotating with a stationary and inhomogeneous velocity profile, regions can appear, where the ion velocity exceeds the group velocity of the phonons. In these regions phonons are trapped like photons in black holes.

Exploiting this analogy known for hydrodynamic systems, we give evidence for the prediction of the thermal distribution of Hawking radiation and present a realistic experimental scenario to measure Hawking radiation. Thus, we propose for the first time an experiment to detect Hawking radiation in a discrete analogue of space time with a nonlinear dispersion relation.

Q 58.5 Fr 11:30 VMP 6 HS-A

Deterministic reordering of ^{40}Ca^{+} ions in a linear, segmented Paultrap — •Maximilian Harlander[1], Michael Brownnutt[1], Felicity Splatt[1], Wolfgang Hänsel[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck, Austria

Segmented ion traps are one of the most promising candidates for a quantum computer technology. In such a system, ions must be shuttled and sorted into different arrangements, dependent on the algorithm being used [1]. The ability to deterministically reorder ions within a linear string is therefore a crucial building block for ion quantum computation in segmented traps. Earlier experiments have demonstrated a success rate of 24% for the exchange of two ions in complex trap structures with junctions [2].

In this experiment, we perform the exchange of two ^{40}Ca^{+} ions in a linear, segmented surface ion trap by rotating the ion string about its centre. Using a simple trap structure, rotations can be achieved by applying appropriate DC voltages in addition to the strictly-linear RF potential. An exchange fidelity of 98% is obtained, and the ion heating is below 1 meV per exchange. This method has also been shown to work with ions of differing masses. [1] D. Kielpinski, C. Monroe, and D.J. Wineland, Nature **417** 709 (2002) [2] W.K. Hensinger, S. Olmschenk, D. Stick, D. Hucul, M. Yeo, M. Acton, L. Deslauriers, and C. Monroe, Appl.Phys.Lett **88** 034101 (2006)

Q 58.6 Fr 11:45 VMP 6 HS-A

Coupling trapped ions via transmission lines — Sankaranarayanan S[1], Sönke Möller[1], Rob Clark[2], •Nikos Daniilidis[1], and Hartmut Häffner[1,3] — [1]Institut für Quantenoptik und Quanteninformation Österreichische Akademie der Wissenschaften, Innsbruck, Austria — [2]Center for Ultracold Atoms, Massachusetts Institute of Technology, Cambridge, MA, USA — [3]Department of Physics, University of California, Berkeley, CA, USA

An oscillating trapped ion induces oscillating image charges in the trap electrodes. If this current is sent to the electrodes of a second trap, it influences the motion of an ion in the second trap. The expected time for a complete exchange of the ion motions is 1 ms for a trap with a characteristic size of 50 μm. This inter-trap coupling may be used for scalable quantum computing, cooling ion species that are not directly accessible to laser cooling, for the non-invasive study of superconductors, and for coupling an ion-trap quantum computer to a solid-state quantum computer, e.g. a system of Josephson junctions.

We are investigating the feasibility of these experiments on microfabricated planar traps. These offer the possibility of multiple independently tunable trapping regions on the same device. We are characterizing the behavior of gold-on-sapphire planar traps in terms of heating rates and micromotion compensation stability. In addition, we discuss trap operation and heating rates in the presence of a floating conductor. The latter will serve as the coupling electrode in experiments aiming at exchange of the motional states of ions in neighboring trapping regions.