Q 50: Kalte Atome: Manipulation und Detektion

Time: Thursday 14:00–16:00 Location: V7.03

Q 50.1 Thu 14:00 V7.03

Fibre-optical tweezers to preparate and interface single atoms — •Dominik Maxein, Sébastien Garcia, Leander Hohmann, Jakob Reichel, and Romain Long — Laboratoire Kastler Brossel UPMC ENS CNRS, 24 rue Lhomond, 75231 Paris Cedex 05

Preparing and manipulating single quantum objects is crucial to explore their interactions and to use them as components in quantum information processing. Atoms can be trapped in a focussed red-detuned laser beam forming an optical dipole trap or "tweezers". Sufficiently small tweezers exhibit the regime of collisional blockade, in which at most one atom stays trapped, making this an advantageous system to prepare single atomic qubits. However, the size and complexity of existing single-atom tweezers experiments impedes their highly desirable combination with other elements such as optical cavities.

Our approach is to simplify and miniaturize single-atom tweezers, turning them into a robust and versatile tool in quantum optics. This is achieved by using a single-mode fibre fixed to a small aspheric lens. This simple system serves the dual purpose of providing strongly focussed trapping light and collecting atomic fluorescence with high numerical aperture. A first implementation has been realized, and the obtained fluorescence signals clearly indicate the trapping of single atoms. We will study the properties of the system and furthermore characterize it as a single-photon source, expecting narrowband emission and good indistinguishability of successive photons. Finally, opportunities for continuing integration of fibre-optical single-atom tweezers and their combination with other experiments will be discussed.

Q 50.2 Thu 14:15 V7.03

Quantum computation with ultracold atoms in driven optical lattices — •Philipp-Immanuel Schneider and Alejandro Saenz — AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstrasse 15, 12489 Berlin, Germany

In the last years tremendous progress has been made in controlling and observing ultracold atoms in optical lattices. One of the latest developments has been the optical detection of atoms with single site resolution in lattices of increasingly smaller periodicity [1,2]. Along with these detection schemes comes the possibility to control the lattice potential with single-site resolution.

We propose a scheme that makes use of these approved technologies to perform quantum computation in optical lattices. The qubits are encoded in the spacial wavefunction of atoms in the Mott insulator phase such that spin decoherence does not influence the computation. Quantum operations are steered by shaking the lattice while the qubits are addressed by locally changing the lattice potential. Numerical calculations show possible fidelities above 99% with gate times on the order of a few milliseconds [3].

[1] W. S. Bakr et al. Nature **462**, 74 (2009).
[2] J. F. Sherson et al. Nature **467**, 68 (2010).
[3] P.-I. Schneider, A. Saenz preprint arXiv:1103.4950

Q 50.3 Thu 14:30 V7.03

Temperature measurement of ultracold atoms using electromagnetically induced transparency — •Frank Blatt[1], Benjamin Wittrock[1], Thorsten Peters[1], Leonid Yatsenko[2], and Thomas Halfmann[1] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, Hochschulstraße 6, 64289 Darmstadt — [2]Institute of Physics, National Academy of Sciences of Ukraine, Prospect Nauki 46, Kiev-39, 03650, Ukraine

Determination of temperatures in ultracold atomic clouds is a crucial requirement for many experiments in quantum optics. Temperature determination is typically realized by time-of-flight (TOF) measurements. The latter is easy to implement and precise - but also slow and destructive to the atomic cloud.

In this talk we present experimental results on temperature measurements in an ultracold atomic cloud by electromagnetically induced transparency (EIT). We compare the data to numerical simulations, as well as temperature measurements by TOF. As an important feature in EIT with two counter propagating beams, the absorption of the probe beam depends on the Doppler broadening, i.e. the temperature of the medium. This enables determination of temperatures from rather simple EIT spectra. The technique is robust, fast and does not destroy or perturb the atomic cloud.

Q 50.4 Thu 14:45 V7.03

Quantum Memory Assisted Probing of Dynamical Spin Correlations — Oriol Romero-Isart[1], •Matteo Rizzi[1], Christine Muschik[1,4], Eugene Polzik[2], Maciej Lewenstein[3,4], and Anna Sanpera[3,5] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Niels Bohr Institute, QUANTOP, Copenhagen University, Denmark — [3]ICREA-Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain — [4]ICFO-Institut de Ciències Fotòniques, Castelldefels, Spain — [5]Departament de Física. Universitat Autònoma de Barcelona, Bellaterra, Spain

We propose a method to probe time dependent correlations of non trivial observables in many-body ultracold lattice gases. The scheme uses a quantum non-demolition matter-light interface, first, to map the observable of interest on the many body system into the light and, then, to store coherently such information into an external system acting as a quantum memory. Correlations of the observable at two (or more) instances of time are retrieved with a single final measurement that includes the readout of the quantum memory. Such method brings at reach the study of dynamics of many-body systems in and out of equilibrium by means of quantum memories in the field of quantum simulators.

Q 50.5 Thu 15:00 V7.03

Classicality from the continuous measurement of a BEC in a double-well potential — •Moritz Hiller[1,2], Thomas Konrad[3,4], Magnus Rehn[3], Francesco Petruccione[3], and Andreas Buchleitner[2] — [1]Institute for Theoretical Physics, Vienna University of Technology, Austria — [2]Fakultät für Physik, Albert-Ludwigs-Universität Freiburg, Germany — [3]Centre for Quantum Technologies, University of KwaZulu-Natal, Durban, South Africa — [4]National Institute of Theoretical Physics, South Africa

We study continuous (unsharp) measurements of a Bose-Einstein condensate (BEC) in a double-well potential. We find, that the interplay between measurement and inter-atomic interactions can drastically reduce the complexity of the quantum many-body wave function – to the extent, that the latter resembles a coherent, i.e., a classical state despite the presence of interactions. We demonstrate that in this regime, the dynamics of the system (including the influence of the measurement) can be monitored faithfully after a certain time. That is, the time-evolving state can be inferred from the measurement signal without destroying the BEC.

Q 50.6 Thu 15:15 V7.03

Efficient quantum state tomography of atoms in optical lattices — •Matthias Ohliger[1,2], Christian Gogolin[1], Vincent Nesme[1], and Jens Eisert[1] — [1]Dahlem center for complex quantum systems, Berlin, Germany — [2]Universität Potsdam, Potsdam, Germany

Due to the high level of experimental control, ultra-cold atoms in optical lattices are almost perfectly suited as a model for various many-body systems. We propose a method for efficient quantum state tomography in such settings, relying only on experimentally feasible techniques like super-lattices, laser-speckles, and time-of-flight measurements. We consider the most general situation of an arbitrary quantum states and discuss the simplifications which occur when the state is of low rank or well approximated by a matrix-product state. Furthermore, we introduce a protocol to certify the success of the tomography procedure based on the measured data.

Q 50.7 Thu 15:30 V7.03

Trapping and guiding atoms on a mesoscopic chip structure — •Jan Mahnke[1], Stefan Jöllenbeck[1], Ilka Geisel[1], Jan Arlt[2], Wolfgang Ertmer[1], and Carsten Klempt[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland — [2]Department of Physics and Astronomy, Aarhus University, Denmark

We investigate guiding and trapping of rubidium atoms on a mesoscopic chip structure with millimeter scale wires. This structure is used to create a quadrupole field for a magneto-optical trap, a magnetic guide and a flexible magnetic trapping potential. In our experiments this allows us to transport cold atoms into a region that provides better vacuum conditions and very effective stray light protection. It is therefore particularly well suited to simultaneously trap and collect atoms. We show that our control of the local magnetic fields and the effective light shielding enable us to load another MOT without significantly reducing the lifetime of previously trapped atoms. This enables reloading the magnetic guide and may lead towards a continuous loading scheme [1].

[1] Continuous loading of a non-dissipative atom trap C. F. Roos et al 2003 Europhys. Lett. 61 187

Q 50.8 Thu 15:45 V7.03

Formation of helical ion chains — •Ramil Nigmatullin[1,2], Adolfo del Campo[3], Gabriele de Chiara[4,5], Giovanna Morigi[6], Martin Plenio[1,2], and Alex Retzker[1] — [1]Ulm University, Ulm, Germany — [2]Imperial College London, London, UK — [3]Los Alamos National Laboratory, Los Alamos, USA — [4]Universitat Autonoma de Barcelona, Barcelona, Spain — [5]Queen's University Belfast, Belfast, UK — [6]University of Saarlandes, Saarbruecken

We study the formation of helices in the structural phase transition of linear Wigner crystals to zigzag Wigner crystals. Wigner crystals are confined radially by a harmonic potential and with periodic boundary conditions in the axial direction, which in principle can be realized experimentally using ring ion traps. Molecular dynamics simulations are used to show that the dependence of the average winding number of the helix is consistent with the prediction of the Kibble-Zurek mechanism.