A 33: Ultracold atoms and BEC - V (with Q)

Time: Friday 11:00–13:00 Location: N 1

A 33.1 Fri 11:00 N 1

Quantum Galvanometer with ultracold atoms — •Carola Rogulj, Peter Federsel, Malte Reinschmidt, Lukas Gussmann, Andreas Günther, and József Fortágh — Physikalisches Institut, Auf der Morgenstelle 14, D-72076 Tübingen

Hybrid quantum systems are engineered to combine properties and advantages of two quantum systems. Heading for novel quantum technologies, ultracold atoms and nanomechanical resonators are promising candidates for quantum information processing. Ultracold atoms and degenerate quantum gases can be very precisely manipulated and provide long coherence times, which makes them for example well suited quantum memories. Nanomechanical oscillators can not only be functionalized to allow for sensitive force detection, but can also be cooled down to their quantummechanical ground state. In my talk, I will show a Quantum Galvanometer scheme and its experimental realisation, where an oscillating nanomechanical resonator carrying electrical current is brought to interaction with a Bose Einstein condensate of ^{87}Rb atoms. This is achieved by means of an atomchip with magnetic conveyor belt. In our case, the resonator consists of a gold coated silicon nitride beam. It creates a fluctuating electromagnetical field which serves as output coupler for an atom laser. We have developed a state and energy selective single atom detection scheme that allows to observe temporal correlations of this atom laser. The magnetomechanically coupled hybrid system will thus enable us to measure the statistics of current fluctuations in a setup that is capable of resolving quantum properties of electrical current.

A 33.2 Fri 11:15 N 1

A deterministic ion source based on ultracold atoms — •Cihan Sahin, Jens Benary, Philipp Geppert, Andreas Müllers, and Herwig Ott — Technische Universität Kaiserslautern

An ion source with minimal energy spread and deterministic emission has many applications in basic research and technical applications including surface spectroscopy, ion implantation or ion interferometry.

We have developed an ion source based on ^{87}Rb atoms confined in a magneto-optical trap. The atoms are ionized with a three photon scheme, built-up of infrared lasers. This results in a minimal energy transfer to the ionization fragments and reduces the electron background from the photoelectric effect.

To detect the electrons and ions, we currently use channel electron multipliers (CEM). The electron, registered within a few ns after ionization, is utilized for the deterministic operation of the ion source. The much slower ions are controlled by a gate electrode, which is by default blocking them. If an electron is registered, the gate is opened for a short time to let the corresponding ion pass.

Currently, we are able to operate the source with an ion rate from a few to 10^4 s^{-1} in gated mode, and 10^6 s^{-1} without gate operation. We discuss the results obtained so far including the statistical properties of our source.

In a next step, the ion CEM will be replaced with a position sensitive detector for ion momentum spectrocopy. Additionally, an adaptive ion optics upgrade may be used to manipulate ion trajectories in real time and allow for aberation corrections.

A 33.3 Fri 11:30 N 1

Ultracold electron source from a MOT studied by ToF-microscopy — •Olena Fedchenko[1], Sergey Chernov[1], Melissa Vielle-Grosjean[2], Gerd Schönhense[1], and Daniel Comparat[2] — [1]Institut für Physik, JGU Mainz, Germany — [2]University Paris-Sud, Orsay, France

We report on the first results of the application of cold Cs atoms as a monochromatic (photo-) electron source obtained with time-of-flight momentum microscopy. Such sources provide an electron beam for high energy resolution (meV-range) spectroscopic electron microscopy [1]. The experimental set-up consists of a magneto-optical trap with Cs atoms, ionization lasers, lens system of the ToF-microscope and delay-line detector [2]. Last two allow mapping of 3D spectral function I(k_x, k_y, t). The ToF study of photoelectron dynamics was performed using pulsed pico- and femtosecond lasers for ionization above or just at the ionization threshold. In the first case a picosecond pulsed LD @ 375 nm was used for the direct ionization from $6p_{3/2}$. In the second case a LD @ 1470 nm (excitation $6p_{3/2} \rightarrow 7s_{1/2}$) was used in combination with a Ti-sapphire laser @ 750-800 nm (ionization from the $7s_{1/2}$). Consequently, varying the initial photoelectron energy in the range from 5 meV up to 860 meV above the ionization limit gives the opportunity to find optimal conditions to get the best electron beam parameters - time and energy spread, emittance, brightness and focusing.

Funded by ANR/DFG HREELM

[1] M. Kitajima et al., Europ. Phys. J. D 66, 130 (2012). [2] A. Oelsner et al., J. Electron Spectrosc. 178-179, 317 (2010).

A 33.4 Fri 11:45 N 1

Realization of uniform synthetic magnetic fields by periodically shaking an optical square lattice — Charles Creffield[1], •Gregor Pieplow[1], Fernando Sols[1], and Nathan Goldman[2] — [1]Departamento de Física de Materiales, Universidad Complutense de Madrid, E-28040 Madrid, Spain — [2]CENOLI, Faculté des Sciences, Université Libre de Bruxelles (U.L.B.), B-1050 Brussels, Belgium

A powerful method to create effective magnetic fields is to shake a lattice of cold gases trapped in an optical lattice. Typically such schemes produce space-dependent effective masses and non-uniform flux patterns. In this work we try to tackle this problem by proposing several lattice shaking protocols, theoretically investigating their associated effective Hamiltonians and their quasienergy spectra. This allows the identification of novel shaking schemes, which simultaneously provide uniform effective mass and magnetic flux, with direct implications for cold-atom experiments and photonics.

A 33.5 Fri 12:00 N 1

Cavity-assisted measurement and coherent control of collective atomic spin oscillators — •Nicolas Spethmann[1,2], Jonathan Kohler[2], Sydney Schreppler[2], and Dan Stamper-Kurn[2,3] — [1]Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Department of Physics, University of California, Berkeley, CA 94720, USA — [3]Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

I will present experiments of continuous measurement and coherent control of the collective spin of an atomic ensemble trapped and evolving in a high-finesse cavity. We employ autonomous optical feedback onto the atomic spin dynamics, conditioned by the cavity spectrum, as a feedback mechanism to stabilize the spin in either its high- or low-energy state. We measure the effective spin temperature from the asymmetry between the Stokes and anti-Stokes sidebands. We demonstrate that such a feedback-stabilized spin ensemble remains in a nearly pure quantum state, in spite of measurement back-action due to the continuous interaction with the probe field. Here, the high-energy spin state corresponds to a state with negative effective temperature. The system realized in our work paves the way for applications in the quantum regime, as for example quantum-limited, phase-preserving spin amplifiers or coherent quantum noise cancellation techniques.

A 33.6 Fri 12:15 N 1

Sudden and Slow Quenches into the Antiferromagnetic Phase of Ultracold Fermions — Monika Ojekhile[1], •Robert Höppner[1], Henning Moritz[2], and Ludwig Mathey[1] — [1]Zentrum für Optische Quantentechnologien and Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany — [2]Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany

We propose a method to reach the antiferromagnetic state of two-dimensional Fermi gases trapped in optical lattices: Independent subsystems are prepared in suitable initial states and then connected by a sudden or slow quench of the tunneling between the subsystems, while subjecting the system to a time-dependent staggered magnetic field. Examples of suitable low-entropy subsystems are double wells or plaquettes, which can be experimentally realised in Mott insulating shells using optical super-lattices. Expanding on previous work reported in Ref. [1], we now investigate the effect of finite quench times and different quench protocols on the final state energy using a the quantum Heisenberg model of a finite system.

[1] Zeitschrift für Naturforschung A., Vol. 71, Issue 12, Pages 1143-1150

A 33.7 Fri 12:30 N 1

Measuring Correlations in a Double Well with Single-Atom Imaging — •Vincent M. Klinkhamer, Andrea Bergschneider, Jan Hendrik Becher, Philine L. Bommer, Justin F. Niedermeyer, Gerhard Zürn, Philipp M. Preiss, and Selim Jochim — Physikalisches Institut der Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

We deterministically prepare quantum states of two interacting Lithium atoms in an optical double-well potential. To recover the occupation number on the sites, we detect individual atoms with our new spin-resolved fluorescence imaging. However, interesting properties such as the symmetry between particles cannot be measured in this way. Therefore we measure the momenta of the individual atoms after time-of-flight expansion. This allows us to determine the correlations between two atoms with high contrast.

A 33.8 Fri 12:45 N 1

Scaling of a long-range interacting quantum spin system driven out of equilibrium — •Stephan Helmrich, Alda Arias, and Shannon Whitlock — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

Complex systems are often found to exhibit unexpectedly simple scaling laws that can signal new physical regimes or universal relations between otherwise very different systems. Although this provides a powerful tool for characterising systems close to equilibrium, there are only few known examples where scaling behavior can be found in dynamical settings. Here we demonstrate power-law scaling in a well-controlled quantum spin system driven out of equilibrium [1]. This enables us to reconstruct the non-equilibrium phase diagram of the system and to identify dissipation-dominated, driving-dominated and interaction-dominated regimes. Comparing the measured scaling laws with kinetic Monte Carlo simulations we uncover the microscopic origin of the observed scalings. This opens up a new means to study and classify quantum systems out of equilibrium and extends the domain where scale-invariant behavior can be found.

[1] S. Helmrich, A. Arias, and S. Whitlock. arXiv:1605.08609, 2016