Q 28: Ultracold Atoms, Ions and BEC II (with A)

Time: Tuesday 14:30–16:30 Location: C/HSW

Q 28.1 Tue 14:30 C/HSW

Structural transitions of nearly second order in classical dipolar gases — •Florian Cartarius[1,2,3], Giovanna Morigi[3], and Anna Minguzzi[1,2] — [1]Laboratoire de Physique et Modélisation des Milieux Condensés, Université Grenoble Alpes, F-38000 Grenoble, France — [2]Laboratoire de Physique et Modélisation des Milieux Condensés, CNRS, F-38000 Grenoble, France — [3]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany

Particles with repulsive power-law interactions undergo a transition from a single to a double chain (zigzag) by decreasing the confinement in the transverse direction. We theoretically characterize this transition when the particles are classical dipoles, polarized perpendicularly to the plane in which the motion occurs, and argue that this transition is of first order, even though weakly. The nature of the transition is determined by the coupling between transverse and axial modes of the chain and contrasts with the behavior found in Coulomb systems, where the linear-zigzag transition is continuous and belongs to the universality class of the ferromagnetic transition. Our results hold for classical systems with power-law interactions $1/r^{\alpha}$ when $\alpha > 2$ and show that structural transitions in dipolar systems and Rydberg atoms can offer a test bed for simulating the critical behavior of magnets with lattice coupling.

Q 28.2 Tue 14:45 C/HSW

Noise spectroscopy with quantum gases — •Peter Federsel, Carola Rogulj, Tobias Menold, Malte Reinschmidt, Andreas Günther, and József Fortágh — Physikalisches Institut, Universität Tübingen, Germany

Local measurements of electric and magnetic field noise are fundamentally important for understanding charge transport in nanoscaled systems. Using a quantum gas, classical and even quantum noise, might be locally detected via magnetic and electric dipole transitions. This way, a quantum galvanometer for measuring current and current noise comes into direct reach[1].

Here we present a state- and energy-selective single atom detection scheme, which can be used to sense magnetic field fluctuations at the atoms' hyperfine and Zeeman transition frequencies. Therefore, atoms which have undergone a transition are ionized and individually detected on a channel electron multiplier. We characterize the bandwidth and sensitivity of this spectrometer by applying external magnetic field fluctuations and find good agreement with theoretical predictions. Using correlation analysis of the time-resolved ion signal, the resolution of the spectrometer can be further increased.

[1] Kalman et al., Nano Letters **12**, 435-439 (2012)

Q 28.3 Tue 15:00 C/HSW

Interferometric Measurement of the Current-Phase Relationship of a Superfluid Weak Link — •Fred Jendrzejewski, Steve Eckel, Avinash Kumar, Christopher J. Lobb, and Gretchen K. Campbell — Joint Quantum Institute, National Institute of Standards and Technology and University of Maryland

Weak connections between superconductors or superfluids can differ from classical links due to quantum coherence, which allows flow without resistance. Transport properties through such weak links can be described with a single function, the current-phase relationship, which serves as the quantum analog of the current-voltage relationship. Here, we present a technique for inteferometrically measuring the current-phase relationship of superfluid weak links. We interferometrically measure the phase gradient around a ring-shaped superfluid Bose-Einstein condensate containing a rotating weak link, allowing us to identify the current flowing around the ring. While our Bose-Einstein condensate weak link operates in the hydrodynamic regime, this technique can be extended to all types of weak links (including tunnel junctions) in any phase-coherent quantum gas. Moreover, it can also measure the current-phase relationships of excitations. Such measurements may open new avenues of research in quantum transport.

Q 28.4 Tue 15:15 C/HSW

Hybrid Quantum Systems of Ultracold Atoms and Superconductors — •Helge Hattermann, Lörinc Sárkány, Patrizia Weiss, Simon Bernon, Daniel Bothner, Benedikt Ferdinand, Matthias Rudolph, Reinhold Kleiner, Dieter Koelle, and József Fortágh — CQ Center for Collective Quantum Phenomena and their Applications, Physikalisches Institut Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

We present recent experimental progress towards coupling between cold atoms and superconducting quantum circuits. We show that atomic ensembles can be trapped magnetically in a superconducting coplanar waveguide resonator, where long-lived atomic superposition states with coherence times on the order of seconds can be prepared. The next research goal will be the resonant coupling between trapped atoms and the superconducting microwave cavity.

Furthermore, we demonstrate the sensitivity of ultracold atomic ensembles to quantized flux in a superconducting ring.

Q 28.5 Tue 15:30 C/HSW

Photoassociation of Chromium — •Jahn Rührig, Tobias Bäuerle, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, Stuttgart, 70569 , Germany

We report the homonuclear photoassociation (PA) [1] of ^{52}Cr atoms while demagnetization cooling [2] in an optical dipole trap. This constitutes the first measurement of PA in an high spin element. Although Cr, with the $^7S_3$ ground and $^7P_3$ excited states, is expected to have a complicated PA spectrum the spin polarized cloud, the applied σ^- light and the absence of hyperfine-splitting lead to a remarkably simple PA spectrum. Within the scan range of 20 GHz we observe two distinct PA series each following a LeRoy-Bernstein law [3] with excellent agreement. We determine the C_3 coefficients of the Hund's case c) [4] adiabatic potentials to be 1.9 a.u. and 1.5 a.u.. Due to the strong spin orbit coupling we compute the full adiabatic potentials [5] to explain the observed C_3 coefficients. In a different set of experiments we can lift the spin-polarization of the cloud by tilting the magnetic field which leads to additional PA series.

[1]:K. M. Jones, Rev. Mod. Phys. 78, 483-535 (2006)
[2]:M. Fattori et al. , Nature Physics 2, 765 (2006).
[3]:R. J. LeRoy et al., J. Chem. Phys. 52, 3869 (1970).
[4]:F. Hund, Zeitschrift für Physik 36, 657-674 (1926).
[5]:M. Movre et al.,J. Phys. B: At. Mol. Phys. 10, 2631 (1977).

Q 28.6 Tue 15:45 C/HSW

Suppression and Revival of Weak Localization through Control of Time-Reversal Symmetry — •Kilian Müller[1], Jérémie Richard[1], Valentin Volchkov[1], Vincent Denechaud[1], Philippe Bouyer[2], Alain Aspect[1], and Vincent Josse[1] — [1]Institut d'Optique, Université Paris Sud 11, Palaiseau, France — [2]Institut d'Optique, Université Bordeaux 1, Talence, France

Phase coherence can have an important effect on the propagation of waves in disorder. Emblematic phenomena are weak localization and coherent backscattering (CBS). At their heart they rely on the constructive interference between time-reversed multiple scattering paths.

We report on the observation of suppression and revival of CBS of ultra-cold atoms launched in an optical disorder and submitted to a short dephasing pulse [1], as proposed in a recent paper of T. Micklitz et al. [2]. This observation, in a quasi-2D geometry, demonstrates a novel and general method to study weak localization by manipulating time reversal symmetry in disordered systems. In future experiments, this scheme could be extended to investigate higher order localization processes at the heart of Anderson (strong) localization.

[1] K. Müller, J. Richard, V.V. Volchkov, V. Denechaud, P. Bouyer, A. Aspect, and V. Josse, arXiv:1411.1671 [2] T. Micklitz, C. A. Müller, and A. Altland, arXiv:1406.6915

Q 28.7 Tue 16:00 C/HSW

Controlling a $\mathcal{PT}$-symmetric double well by an additional well — •Daniel Haag, Dennis Dast, Holger Cartarius, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart

Non-Hermitian Hamiltonians provide an efficient way to describe in- and outcoupling of atoms in Bose-Einstein condensates. Of special interest are $\mathcal{PT}$-symmetric Hamiltonians which often provide $\mathcal{PT}$-symmetric eigenstates with real eigenvalues. These states are truly stationary even though the particles are removed and injected at different locations. We implement such a Hamiltonian for a three-mode system, where one additional well is coupled to a $\mathcal{PT}$-symmetric double well. The influences of the third well on the well known behaviour of the two-well system is studied.

Q 28.8 Tue 16:15 C/HSW

Quantum master equation for a BEC with balanced gain and loss — •Dennis Dast, Daniel Haag, Holger Cartarius, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart

BECs with balanced gain and loss have been extensively studied in the mean-field limit using a non-Hermitian but $\mathcal{PT}$-symmetric Gross-Pitaevskii equation. However, a microscopic description is desirable since the only physical process capable of describing a gain and loss of the condensate's wave function is the injection and removal of single particles. We present a quantum master equation in Lindblad form whose mean-field limit is a $\mathcal{PT}$-symmetric Gross-Pitaevskii equation. The master equation supports the characteristic properties of $\mathcal{PT}$-symmetric systems such as the existence of stationary states even for a relatively small number of particles. Furthermore it allows us to investigate many-particle effects of systems with balanced gain and loss which are not accessible in the mean-field limit.