Austria

We study the dynamics of an F=1 spinor Bose-Einstein condensate in one spatial dimension out of equilibrium by means of semi-classical simulations. Our main focus lies on sudden quenches within the paramagnetic phase, where the system is quenched near the critical point of a phase transition by varying an external magnetic field. The time evolution of the resulting non-equilibrium state including quantum effects is studied within the framework of the truncated Wigner approximation. To this end, the coupled Gross-Pitaevskii equations for the fundamental fields are solved numerically using higher-order time-splitting Fourier pseudospectral methods. We observe the formation of soliton-like excitations and study their link to the build-up of correlations in the system. By continuously tuning the interaction away from an integrable point of the system, we further investigate the effects of non-integrability on the observed dynamics. Our results are put into relation with the concept of non-thermal fixed points and critical phenomena.

Q 31.8 Tue 17:00 P OGs

Dynamics of a one-dimensional two-component Bose gas quenched to criticality. — •Martin Rabel, Markus Karl, and Thomas Gasenzer — Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany

We study the dynamics of a two-component Bose gas after a parameter quench into the proximity of a quantum critical point using analytical, real-time effective-action techniques. The relative degrees of freedom within the system can be described by a quasi-spin 1/2 model. This model is subject to a mean-field paramagnetic to ferromagnetic quantum phase transition. For the full model this corresponds to a transition from a miscible to an immiscible phase. The transition is investigated in a dynamical setup: The initial state is the ground-state configuration far away from criticality. Following a sudden quench to criticality the time evolution of the emerging spin fluctuations is analysed. In the one-dimensional system under investigation, the non-vanishing energy introduced by the quench leads to a finite correlation length during the induced time evolution. The finite critical correlation length is determined within a leading-order $1/N$ approximation. The obtained analytical results are compared with Truncated-Wigner numerical simulations.

Q 31.9 Tue 17:00 P OGs

Goldstone mode in the quench dynamics of an ultracold BCS Fermi gas: A full Bogoliubov-de Gennes approach — •Peter Kettmann[1], Simon Hannibal[1], Mihail Croitoru[2], Vollrath Martin Axt[3], and Tilmann Kuhn[1] — [1]Institute of Solid State Theory, University of Münster — [2]Condensed Matter Theory, University of Antwerp — [3]Theoretical Physics III, University of Bayreuth

Ultracold Fermi gases are a convenient system to probe and study the properties of phases like the BEC and the BCS phase and the crossover in between those regimes. In particular, ultracold Fermi gases can be used as a test bed to study the two fundamental dynamical modes –the Higgs and the Goldstone mode– which result from spontaneous symmetry breaking in these phases.

We investigate the Goldstone mode in the dynamics of a cigar-shaped cloud of ultracold ^{6}Li after an interaction quench on the BCS side of the BCS-BEC crossover. To this end, we numerically solve Heisenberg's equations of motion for the Bogoliubov single-particle excitations in the framework of the Bogoliubov-de Gennes (BdG) formalism. Extending previous studies, we use a full BdG approach instead of the truncated Anderson solution. This improves the validity in the strong-coupling regime and ensures a correct coupling of the Goldstone mode to the trapping potential.

We study the impact of this extension on the dynamics of the single-particle excitations and find an overall good qualitative agreement of both solutions. However, some significant deviations occur predominantly in the case of strong coupling.

Q 31.10 Tue 17:00 P OGs

Universal scaling and non-thermal fixed points in spin systems — •Stefanie Czischek[1], Halil Cakir[1], Markus Karl[1], Michael Kastner[2], Markus K. Oberthaler[1], and Thomas Gasenzer[1] — [1]Kirchhoff-Institut für Physik, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany — [2]Institute of Theoretical Physics, University of Stellenbosch, Stellenbosch 7600, South Africa

We study the dynamical build-up of correlations after sudden quenches in spin systems using the discrete truncated Wigner approximation. In particular, we consider quenches from large external fields into the vicinity of a quantum critical point within the paramagnetic phase. We calculate correlation lengths and study their time evolution at different distances from the critical point. For the transverse-field Ising chain, we find that the discrete truncated Wigner approximation is in good agreement with exact analytical and numerical results. Our exact results show that the correlation function takes the form given by a generalized Gibbs ensemble already after short times and small relative distances, which is also found in the discrete truncated Wigner approximation. The agreement of both results for quenches into the vicinity of the critical point suggests that the discrete truncated Wigner approximation may be used to determine the correlation dynamics after quenches for spin systems which are not exactly solvable, in one and higher dimensions.

Q 31.11 Tue 17:00 P OGs

Probing Relaxation at the Many-Body Localization Transition with Ultracold Fermions in Optical Lattices — •Sebastian Scherg[1,2], Henrik Lüschen[1,2], Pranjal Bordia[1,2], Ulrich Schneider[1,2,3], and Immanuel Bloch[1,2] — [1]Ludwig-Maximilians-Universität, Schellingstr. 4, 80799 München, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [3]Cavendish Laboratory, University of Cambridge, J. J. Thomson Avenue, Cambridge CB3 0HE, United Kingdom

The phenomenon of Many-Body Localization (MBL) describes a generic non-thermalizing phase in which quantum information can persist locally up to infinite times. This phase is separated from a phase obeying the Eigenstate Thermalization Hypothesis via a disorder driven, dynamical phase transition, which happens not only in the ground state but over an extended range of excited states. While the dynamical structure deep in the MBL phase is arguably well understood in one dimension, there is a paucity of results close to the critical point and in higher dimensions.

In this work, we report on the observation of MBL in one and two dimensions. We directly probe the transition points finding critically slow relaxation below the critical disorder strength in both 1D and 2D. The slow dynamics in 1D can be attributed to Griffiths type effects. We highlight the importance of interactions, which strongly govern the behavior around the critical point.

Q 31.12 Tue 17:00 P OGs

Sub-Doppler laser cooling of fermionic 40K atoms in gray optical molasses — •Max Hachmann, Robert Büchner, Raphael Eichberger, and Andreas Hemmerich — Institut für Laser-Physik, Universität Hamburg

Most experiments on quantum degenerate gases begin with a laser cooling phase that is followed by evaporative cooling in a conservative trap. The final quantum degeneracy strongly depends on the temperature at the end of the laser cooling phase and sub-Doppler cooling is often a key ingredient for initiating efficient evaporation. In our experiment for fermionic 40K a cooling cycle on the D2 transition for a bright optical molasses has been used. However, 40 K features a narrow hyperfine structure in the excited state of the D2 transition that hinders efficient sub-Doppler cooling by cooling to the red of this transition. The same is true for other isotopes of potassium and lithium. To overcome this limitation a gray molasses cooling scheme on the D1 transition at 770 nm can be implemented to produce cold and dense atomic samples. Here we report on the current progress of the experimental implementation.

Q 31.13 Tue 17:00 P OGs

Fermi Surface Deformation in Dipolar Fermi Gases — •Vladimir Veljić[1], Antun Balaž[1], and Axel Pelster[2] — [1]Scientific Computing Laboratory, Center for the Study of Complex Systems, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Physics Department and Research center OPTIMAS, Technical University of Kaiserslautern, Germany

In a recent time-of-flight (TOF) expansion experiment with ultracold polarized fermionic erbium atoms, TOF images show that the atomic cloud has an ellipsoidal shape, with an elongation in the direction of atomic dipoles [1]. The Hartree-Fock mean-field theory presented in Refs. [2,3], which was restricted to the orientation of dipoles along one of the harmonic trap axes, is generalized here for an arbitrary orientation of dipoles. Afterwards, using this approach we analyze the resulting Fermi surface deformation, calculate TOF dynamics, and solve the corresponding Boltzmann-Vlasov equation within the relaxation-time approximation in the vicinity of a new equilibrium configuration by using a suitable rescaling of the equilibrium distribution. The resulting ordinary differential equations of motion for the scaling parameters are solved numerically for experimentally relevant parameters at zero temperature. A comparison of our analytical and numerical results with the Innsbruck experimental results [1] is also presented.

[1] K. Aikawa, et al., Science **345**, 1484 (2014).
[2] F. Wächtler, A.R.P. Lima, and A. Pelster, `arXiv:1311.5100` (2013).
[3] V. Veljić, A. Balaž, and A. Pelster, `arXiv:1608.06448` (2016).

Q 31.14 Tue 17:00 P OGs

Towards second sound in a quasi two dimensional Fermi gas — •Daniel Hoffmann, Thomas Paintner, Wolfgang Limmer, and Johannes Hecker Denschlag — Universität Ulm, Institut für Quantenmaterie, Deutschland

Excitations in ultracold quantum gases have become a versatile tool to unveil fundamental thermodynamics. Especially the properties of superfluidity have been investigated extensively using local or global excitations. One phenomena which has recently been demonstrated in a quantum gas experiment is second sound excitation (see [1]). In this experiment entropy waves were excited in a suprafluid/normal fluid mixture and were detected by means of density modulation.

In the project presented here, we extend the work on second sound to quasi two dimensional gases. We use a degenerate Fermi gas of ^{6}Li loaded into a highly anisotropic trap, where the conditions of a quasi 2D Fermi gas can be fulfilled. To excite second sound, we use an intensity-modulated laser beam focused on the trap center to generate entropy waves. Detecting density modulations in the Fermi gas enables us to extract the second sound excitation. Our presentation shows first results towards second sound in a quasi 2D interacting Fermi gas.

[1]: Sidorenkov et al., Nature 498, 78-81 (2013)

Q 31.15 Tue 17:00 P OGs

Quench dynamics and equilibrium behavior in a spinless Fermi-Hubbard ladder with dipolar interactions — •Philipp Fabritius and Shannon Whitlock — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

We report on theoretical simulations of a spinless Fermi-Hubbard model on a two-leg ladder with anisotropic long-range dipolar interactions. Using a density-matrix renormalization group approach we obtain the quantum phase diagram. We also present results on the dynamical evolution of the system following a quantum quench from an insulating to an interlayer superfluid phase. These results have relevance for future experiments which aim to use quantum gas microscopy to reveal exotic superfluid and magnetic phases with ultracold atoms.

Q 31.16 Tue 17:00 P OGs

An experiment to initialize and study the Fermi-Hubbard model atom by atom — •Phillip Wieburg, Kai Morgener, Thomas Lompe, and Henning Moritz — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Investigating the Fermi-Hubbard model with cold atoms is typically done by evaporatively cooling an ultracold Fermi gas and loading it into a large optical lattice. In contrast, we plan to build up a Fermi-Hubbard system site by site using optical microtraps. Each microtrap will contain a single atom cooled to the vibrational ground state by Raman-sideband cooling. This technique combines fast experimental cycle times with single site addressability and detection and allows studying the fundamental processes governing the Fermi-Hubbard model in a bottom-up approach.

Here we report upon the commissioning of this new experiment, which is going to be able to cool a gas of 40K to quantum degeneracy as well as to directly lasercool single atoms into optical microtraps. We have already lasercooled 39K and 40K atoms and trapped them magnetically. Further cooling of the atoms will be performed using Raman-sideband cooling [1,2]. In order to image and to manipulate the atoms with high spatial resolution, our setup is equipped with a novel type achromatic imaging system located inside the vacuum chamber.

[1] A.M. Kaufman et al., Physical Review X 2 041014 (2012).
[2] L. W. Cheuk et al., Phys. Rev. Lett. 114, 193001 (2015).

Q 31.17 Tue 17:00 P OGs

Anomalous heating in ion traps: where does the noise originate? — •Carsten Henkel[1], Henning Kaufmann[2], and Ulrich Poschinger[2] — [1]Universität Potsdam — [2]Johannes-Gutenberg-Universität Mainz

Trapped ions that are laser-cooled to the ground state of a Paul trap provide a promising platform for quantum information processing and surface analysis. The ions are subject to fluctuating electric fields emanating from the surrounding electrodes which lead to a finite heating rate whose detailed behaviour is not yet fully understood (patch potentials, surface adsorbates, temperature and distance dependence ...)[1]. Building on a recent model with metallic electrodes covered by a thin lossy dielectric [2], we investigate the spatial distribution of the charge fluctuations that generate the electric field noise. We analyze for example the interference that is at the origin of the maximum of noise for films with a certain thickness [3, 4]. The aim is to mitigate anomalous heating with suitably coated electrodes that screen the dominant noise sources.

[1] M. Brownnutt, M. Kumph, P. Rabl, and R. Blatt, Rev. Mod. Phys. 87 (2015) 1419
[2] M. Kumph, C. Henkel, P. Rabl, M. Brownnutt, and R. Blatt, New J. Phys. 18 (2016) 023020
[3] S. Bauer, Am. J. Phys. 60 (1992) 257
[4] S. A. Biehs, D. Reddig, and M. Holthaus, Eur. Phys. J. B 55 (2007) 237; S. A. Biehs, Eur. Phys. J. B 58 (2007) 423

Q 31.18 Tue 17:00 P OGs

A hybrid atom-ion trap for ultracold Li and Yb$^+$ — •Jannis Joger[1], Henning Fürst[1], Norman Ewald[1], Thomas Secker[2], Thomas Feldker[1], and Rene Gerritsma[1] — [1]Institute of Physics, University of Amsterdam, Netherlands — [2]Institute for Coherence and Quantum Technology, TU Eindhoven, Netherlands

Our setup for realising a hybrid system of ultra-cold atoms and ions is presented. This setup allows studying the quantum dynamics of mixtures of fermionic atoms and ions. Recent experiments have shown that the time-dependent trapping field of the ions can cause heating in hybrid atom-ion systems [1]. One way to mitigate this problem is to employ ion-atom combinations with a large mass ratio [2]. The highest convenient mass ratio - for species that still allow for straightforward laser cooling - is achieved by using the combination ^{171}Yb$^+$ and ^{6}Li.

Combining ion trapping technology with ultra-cold lithium poses particular challenges that we address on this poster. We present numerical simulations showing that the s-wave limit may be reached in our setup, opening up the possibility of studying atom-ion Feshbach resonances [3] and show our first experimental results of atom-ion interactions.

[1] Z. Meir et al., arXiv:1603.01810 (2016)
[2] M. Cetina et al., Phys. Rev. Lett. 109, 253201 (2012).
[3] M. Tomza, C.P. Koch and R. Moszynski, Phys. Rev. A 91, 042706 (2015).

Q 31.19 Tue 17:00 P OGs

Laser cooling of Dysprosium — •Niels Petersen, Florian Mühlbauer, Carina Baumgärtner, Lena Maske, and Patrick Windpassinger — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

Ultra-cold dipolar quantum gases enable the study of many-body physics with long-range, inhomogeneous interaction effects due to the anisotropic character of the dipole-dipole interaction. These systems are expected to show novel exotic quantum phases and phase transitions which can be studied with dysprosium atoms. Dysprosium is a rare-earth element with one of the largest ground-state magnetic moments (10 Bohr magnetons) in the periodic table. Therefore, the dipole-dipole interaction is not a small perturbation but becomes comparable in strength to the s-wave scattering. This influences significantly the physical properties of the trapped atomic sample, such as its shape and stability.

This poster presents the current status of our experimental setup to generate dysprosium quantum gases. We discuss the relevant properties of dysprosium and present our laser system and vacuum design. We present spectroscopic measurements of the relevant cooling transitions and show our progress towards laser cooling of dysprosium atoms in a magneto optical trap.

Q 31.20 Tue 17:00 P OGs

The role of particle (in-)distinguishability for many-particle dynamics in optical lattices — •Tobias Brünner, Gabriel Dufour, Alberto Rodriguez, and Andreas Buchleitner — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg, Germany

Much attention has been dedicated so far to the dynamical impact of