Q 25: Quantum Gases (Fermions) I

Time: Monday 16:15–18:00 Location: K 1.022

Q 25.1 Mon 16:15 K 1.022

Probing homogeneous two-dimensional Fermi gases in momentum space — •Lennart Sobirey, Niclas Luick, Klaus Hueck, Fynn Förger, Jonas Siegl, Thomas Lompe, and Henning Moritz — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Ultracold two-dimensional Fermi gases are uniquely suited to investigate the interplay of reduced dimensionality and strong interactions in quantum many-body systems. Here, we report on our realization of an ultracold 2D Fermi gas trapped in a homogeneous disk-shaped potential. This system is ideally suited to measure non-local quantities such as correlation functions and the momentum distribution. Furthermore, homogeneous systems simplify the creation of quantum phases which exist only in narrow regions of the phase diagram. To confine the homogeneous gas, we radially confine it by a ring-shaped blue-detuned beam with steep walls. We perform matter wave focusing to extract its momentum distribution and directly observe Pauli blocking in a near unity occupation of momentum states.

Q 25.2 Mon 16:30 K 1.022

Ground State of a Fermi Gas with Tilted Dipoles — •Vladimir Veljić[1], Aristeu R. P. Lima[2], Simon Baier[3], Lauriane Chomaz[3], Francesca Ferlaino[4,5], Axel Pelster[5], and Antun Balaž[1] — [1]Center for the Study of Complex Systems, Institute of Physics Belgrade, University of Belgrade, Serbia — [2]University for International Integration of the Afro-Brazilian Lusophony, Brazil — [3]Institute for Experimental Physics, University of Innsbruck, Austria — [4]Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Innsbruck, Austria — [5]Physics Department and Research Center OPTIMAS, Technical University of Kaiserslautern, Germany

In the presence of an anisotropic and long-range dipole-dipole interaction, the Fermi sphere of an ultracold Fermi gas deforms into an ellipsoid. Recently, it was experimentally observed in such systems that the shape of the Fermi surface follows the rotation of the dipoles when they are tilted [1]. Here we generalize the Hartree-Fock mean-field theory of Refs. [2, 3], where the dipoles were assumed to be parallel to one of the trap axes, to an arbitrary orientation of the dipoles and obtain the ground-state Thomas-Fermi radii and momenta. The calculated angular dependence of the Fermi surface deformation shows good agreement with experimental observations. We also find that the angular dependence of the aspect ratio turns out to be a direct consequence of the dipole tilting.

[1] K. Aikawa, et al., Science **345**, 1484 (2014).
[2] F. Wächtler, et al., Phys. Rev. A **96**, 043608 (2017).
[3] V. Veljić, et al., Phys. Rev. A **95**, 053635 (2017).

Q 25.3 Mon 16:45 K 1.022

High temperature pairing in a strongly interacting two-dimensional Fermi gas — •Luca Bayha[1], Puneet Murthy[1], Mathias Neidig[1], Ralf Klemt[1], Igor Boettcher[2], Tilman Enss[3], Marvin Holten[1], Gerhard Zürn[1], Philipp Preiss[1], and Selim Jochim[1] — [1]Physikalisches Institut, Universität Heidelberg — [2]Department of Physics, Simon Fraser University — [3]Institut für Theoretische Physik, Universität Heidelberg

Understanding the nature of the normal phase of strongly correlated Fermi systems is a fascinating open question in many-body physics.
In this talk I will present recent measurements, where we observe many-body pairing in a strongly interacting quasi two-dimensional ultracold Fermi gas at temperatures far above critical temperature for superfluidity. We employ spatially resolved radio-frequency spectroscopy to probe the pairing energy in the system. We identify and study a regime in the normal phase, where the pairing gap shows a clear density dependence and significantly exceeds the intrinsic two-body binding energy. This implies that pairing in this regime is driven by many-body correlations, rather than two-body physics. These correlations are remarkably robust against thermal fluctuations, as the effects persist up to temperatures close to the Fermi-temperature.

Q 25.4 Mon 17:00 K 1.022

Anomalous breaking of scale invariance in a two-dimensional Fermi gas — •Marvin Holten, Luca Bayha, Antonia Klein, Puneet Murthy, Philipp Preiss, and Selim Jochim — Physikalisches Institut, University of Heidelberg, Germany

The frequency of the breathing mode of a classical, two-dimensional Fermi gas in a harmonic confinement is fixed by the scale invariance of the Hamiltonian. On the quantum mechanical level, however, scale invariance is broken by introducing the two dimensional scattering length a_{2D} as a regulator. This is an example for a quantum anomaly in the field of ultracold atoms and leads to a shift of the frequency of the collective breathing mode of the cloud. In this talk, I present our experimental study of this frequency shift for a two component Fermi gas in the strongly interacting regime. We observe a significant shift away from the scale invariant result that depends on both interactions and temperature. A careful consideration of all the additional terms that may lead to explicit breaking of scale invariance is required to distinguish those from the effects caused by the anomaly.

Q 25.5 Mon 17:15 K 1.022

Violation of the Wiedemann-Franz law in a unitary Fermi gas — •Samuel Häusler, Dominik Husmann, Martin Lebrat, Philipp Fabritius, Laura Corman, Jean-Philippe Brantut, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, 8093 Zürich, Switzerland

In materials heat and particle transport are often coupled, leading to thermoelectric effects. A temperature gradient may cause particle transport (Seebeck effect) and a variation in chemical potential can induce heat currents (Peltier effect). These phenomena are suited to probe the fundamental excitations that are challenging to identify in strongly correlated matter.

To study these phenomena, we prepare a system consisting of two reservoirs of fermionic lithium atoms at unitarity close to the superfluid transition. After heating one of the reservoirs they may exchange particles and heat through a quantum point contact. We observe a violent initial particle current from cold to hot that brings the system to a non-equilibrium steady state where currents vanish in the presence of finite temperature difference and chemical potential bias. The steady state reveals a finite particle and suppressed thermal conductance strongly violating the Wiedemann-Franz law, which relates the two conductances by a universal number in the limit of low temperatures. This violation signals a breakdown of Fermi liquid behaviour and remains for wider channel geometries, where the system relaxes back to equilibrium. These findings are related to the celebrated fountain effect in bosonic helium II.

Q 25.6 Mon 17:30 K 1.022

Observation of the Higgs mode in the superfluid BEC-BCS crossover in Fermi gases — •Johannes Kombe, Jean-Sébastien Bernier, and Corinna Kollath — Uni Bonn, Nussallee 14-16, 53115 Bonn

Thanks to recent advances, investigating the non-equilibrium dynamics of interacting systems is now possible. Using time-dependent perturbations, one can probe from a different angle the mechanisms responsible for the collective phenomena present in correlated systems. Taking advantage of this progress, we investigate both theoretically and experimentally the evolution of a three-dimensional Fermi gas while the interaction strength is effectively modified. Our study, carried out on the BCS side, reveals various collective excitations. Interestingly, this approach highlights the presence of the Higgs mode.

Q 25.7 Mon 17:45 K 1.022

Spinor Gases of Fermionic Erbium Atoms — •Jan Hendrik Becher[1,3], Simon Baier[1], Lauriane Chomaz[1,2], Gabriele Natale[1], Daniel Petter[1], Manfred Mark[1,2], and Francesca Ferlaino[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria — [3]Physikalisches Institut, Heidelberg University, Germany

Over the last decade, dipolar quantum gases have become an ideal system to study novel phenomena in ultracold quantum physics. In particular, strongly magnetic atomic species, such as erbium, open fascinating possibilities to investigate dipole-dipole interaction (DDI) and its impact on few- and many-body effects in ultracold spinor gases.

Here we report on first experimental investigations of spin physics in fermionic erbium, ^{167}Er. Due to its large quantum numbers, fermionic erbium has a remarkably large number of spin states in the lowest level manifold, $F = 19/2$. The 20 different m_F states interact via both contact and DDI. The DDI is violating spin conservation and effects the dynamics of out-of-equilibrium spin systems.

In the experiment, we create a spin polarized, degenerate Fermi gas in the absolute lowest Zeeman sublevel. We then load the atomic sample into a 3D optical lattice and start spin preparation by applying a radio frequency pulse. In this setting, we study the interaction in the proximity of homonuclear p-wave Feshbach resonances and discover new interspin Feshbach resonances. Furthermore we investigate the dynamics of spin excitations in the frozen-particle regime.