Q 33: Quantum Gases

Time: Wednesday 14:00–15:30 Location: Q-H10

Q 33.1 Wed 14:00 Q-H10

First and Second Sound in a compressible 3D Bose fluid — •Timon A. Hilker[1,2], Lena H. Dogra[1], Christoph Eigen[1], Jake A. P. Glidden[1], Robert P. Smith[3], and Zoran Hadzibabic[1] — [1]University of Cambridge — [2]Max Planck Institute of Quantum Optics — [3]University of Oxford

One of the hallmarks of superfluidity is the existence of two distinct sound modes with the same wavelength. In the incompressible-liquid regime, this phenomenon has been extensively studied with superfluid Helium.

In this talk, I will present our observation and characterization of first and second sound in a compressible 3D ultracold Bose gas. Using a magnetic field gradient, we excite center-of-mass oscillations of a homogeneous K-39 Bose gas in a box trap revealing two distinct resonances. We find quantitative agreement with the hydrodynamic description of Landau's two-fluid model, both for the sound speeds and for the mode structure in terms of in-phase/out-of-phase oscillations dominated by the thermal/BEC atoms for the first/second sound. In addition, we study the full crossover from the hydrodynamic to the collisionless regime above T_c and find a decreasing speed of sound with increasing damping.

Q 33.2 Wed 14:15 Q-H10

Quantum gas microscopy of ultracold cesium atoms — •Alexander Impertro[1,2,3], Julian Wienand[1,2,3], Sophie Häfele[1,2,3], Till Klostermann[1,2,3], Hendrik von Raven[1,2,3], Scott Hubele[1,2,3], Cesar Cabrera[1,2,3], Immanuel Bloch[1,2,3], and Monika Aidelsburger[1,2] — [1]Ludwig-Maximilians-Universität, Schellingstraße 4, 80799 München, Germany — [2]Munich Center for Quantum Science and Technology, Schellingstraße 4, 80799 München, Germany — [3]MPI für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

Ultracold cesium atoms provide a promising experimental platform for quantum simulation of topological many-body phases in the presence of interactions. This is due to a convenient control of the scattering length via a low-lying Feshbach resonance and the possibility to engineer state-dependent lattices. Additionally, high-resolution imaging techniques allow the probing of novel experimental observables at the single-atom and single-site level. In this new quantum gas microscope, we prepare a 2D sample of ultracold cesium atoms in optical lattices and probe them using fluorescence imaging. As a first step towards studying topological quantum phases, we demonstrate the preparation of a bosonic Mott-insulating state. Additionally, we present how we employ machine learning techniques to reconstruct the site-resolved lattice occupation despite a lattice spacing that is more than a factor of two smaller than the imaging resolution.

Q 33.3 Wed 14:30 Q-H10

Interference of composite particles — •Mama Kabir Njoya Mforifoum, Gabriel Dufour, and Andreas Buchleitner — Institut of Physics, Albert-Ludwigs university of Freiburg

The dynamics of systems of identical particles are characterized by many-body interference. However, the interfering particles (bosons or fermions) can be composite objects, raising the question of the conditions under which bound states of several particles behave as ideal elementary bosons or fermions. Here, we consider the dynamics on a 1D lattice of two composite bosons, each a bound state of two elementary fermions or bosons, and observe their Hong-Ou-Mandel interference on a potential barrier. We compare numerically exact simulations of the composite particles' dynamics with an effective model for tightly bound pairs. The latter allows us to identify parameter regimes where the composite objects exhibit strong bosonic interference.

Q 33.4 Wed 14:45 Q-H10

Towards Bose polarons in an ultracold Fermi-Bose mixture of ^{6}Li and ^{133}Cs — •Tobias Krom[1], Binh Tran[1], Eleonora Lippi[1], Michael Rautenberg[1], Manuel Gerken[1], Robert Freund[1], Bing Zhu[1,2], Tilman Enss[3], Manfred Salmhofer[3], Lauriane Chomaz[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Ruprecht Karl University of Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China — [3]Institut for Theoretical Physics, Ruprecht Karl University of Heidelberg, Philosophenweg 19, 69120 Heidelberg, Germany

Experiments with a mixture of ultracold gases allow to probe the behavior of impurities in an environment. In our experiment we are working with the highest possible mass ratio between the impurity and the environment which can be achieved with stable alkali atoms. We are currently aiming for the creation a Bose polaron quasiparticle which describes a single Li impurity inside a Cs BEC. This scenario can be mapped to the Fröhlich polaron model in condensed matter physics.

We describe the trap arrangement and the cooling scheme which will allow us to reach a degenerate Fermi gas and a BEC within one setup. Finally, we will overlap the two ultracold gases while keeping them within their own dipole trap. Furthermore, we give an overview of the necessary characterization steps of our system and the approach towards the experimental observation of the Bose polaron.

Q 33.5 Wed 15:00 Q-H10

From heteronuclear Efimov effect to Fermi polarons - (quasi-) bound states and induced scattering properties — •Michael Rautenberg[1], Binh Tran[1], Tilman Enss[2], Manuel Gerken[1], Eleonora Lippi[1], Bing Zhu[1,3], Juris Ulmanis[1], Moritz Drescher[2], Manfred Salmhofer[2], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Ruprecht Karl University of Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Institut for Theoretical Physics, Ruprecht Karl University of Heidelberg, Philosophenweg 19, 69120 Heidelberg, Germany — [3]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China

We report on the results of our theoretical investigation of two heavy bosons immersed in a Fermi sea of light fermions. Using the Born-Oppenheimer approximation - allowing an effective few-particle description of this quantum many-body problem - both the bound state spectrum as well as fermion-induced scattering properties of the bosons are investigated. The bound state spectrum is discussed as a function of inter- and intraspecies interactions as well as the fermion density, also including the zero density limit where the system recovers the three-body Efimov spectrum. Numerical calculations of potentials and spectra are performed for the mass ratio of a ^{6}Li-^{133}Cs mixture.

Additionally, we find resonances in the induced boson-boson scattering length at the positions where the in-medium Efimov bound states cross the continuum threshold. For sufficiently large impurity-bath mass ratio, quasibound states can be observed.

Q 33.6 Wed 15:15 Q-H10

Thouless Pumps and Bulk-Boundary Correspondence in Higher-Order Symmetry-Protected Topological Phases — •Julian Wienand[1,2], Friederike Horn[1], Monika Aidelsburger[1], Julian Bibo[3], and Fabian Grusdt[1] — [1]Department of Physics, Ludwig-Maximilians-Universität München, Theresienstr. 37, D-80333 Munich, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, D-85748 Garching, Germany — [3]Department of Physics, T42, Technical University of Munich, D-85748 Garching, Germany

The bulk-boundary correspondence relates quantized edge states to bulk topological invariants in topological phases of matter. In symmetry-protected topological systems (SPTs), this fundamental concept is revealed by quantized topological Thouless pumps. Higher-order topological phases of matter (HOSPTs) also feature a bulk-boundary correspondence, but its connection to quantized charge transport remains elusive. In this talk we will show that quantized Thouless pumps connecting C_4-symmetric HOSPTs can be described by a tuple of four Chern numbers that measure quantized bulk charge transport in a direction-dependent fashion. This tuple of Chern numbers allows to predict the sign and value of the fractional corner charges. We show that the topologically non-trivial phase can be characterized by both quadrupole and dipole configurations, shedding new light on current debates about the multi-pole nature of the HOSPT bulk. Our approach paves the way for an in-depth description of future dynamical experiments.