A 8: Ultra-cold atoms, ions and BEC II (with Q)

Time: Monday 14:00–16:00 Location: BEBEL E34

A 8.1 Mon 14:00 BEBEL E34

Bose-Einstein condensates in complex $\mathcal{PT}$-symmetric potentials - a finite element approach — •Daniel Haag, Dennis Dast, Holger Cartarius, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart

$\mathcal{PT}$-symmetric systems have been intensively studied in optical waveguides where the $\mathcal{PT}$ symmetry is achieved by pumping and absorption processes. In such systems the $\mathcal{PT}$ symmetry leads to a wide range of effects promising technical and scientific applications. By analogy, balanced gain and loss of particles in Bose-Einstein condensates can be described by introducing a $\mathcal{PT}$-symmetric imaginary potential into the Gross-Pitaevskii equation. This equation is solved for various three-dimensional complex potentials using the finite element method.

A 8.2 Mon 14:15 BEBEL E34

Dimensional BCS-BEC Crossover — •Igor Boettcher[1], Jan Martin Pawlowski[1,2], and Christof Wetterich[1] — [1]Institute for Theoretical Physics, Heidelberg University, Germany — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum fuer Schwerionenforschung mbH, Darmstadt, Germany

We investigate how the reduction of spatial dimension influences superfludity of two-component fermions in the BCS-BEC crossover by means of the Functional Renormalization Group. Our approach allows to study the system over the whole parameter space of interaction strength, density, temperature, spin-imbalance, and dimension. The high precision and tunability of recent experiments then allows for a solid benchmarking. We present results on the equation of state and the phase diagram as a function of dimension, and compare with recent measurements.

A 8.3 Mon 14:30 BEBEL E34

Extracting entanglement from identical particles in BECs — •Nathan Killoran, Marcus Cramer, and Martin B. Plenio — Institut für Theoretische Physik, Albert-Einstein-Allee 11, Universität Ulm, D-89069 Ulm, Germany

When identical particles occupy the same spatial mode, such as in BECs, the notion of entanglement must be treated carefully. Because of symmetrization, such systems exhibit strong correlations, which appear as entanglement amongst the particles. But the identical particles are not individually accessible, so it is often assumed that such entanglement is unphysical and cannot be used for typical quantum information tasks. In this talk, we show that any apparent entanglement between identical particles can be faithfully transferred into entanglement between independent modes, which can then be applied to any standard quantum information protocol. We thus clarify and quantify the resource nature of entanglement between identical particles in BECs.

A 8.4 Mon 14:45 BEBEL E34

Collective modes in dipolar bosonic bilayers — •Alexey Filinov[1,2] and Michael Bonitz[1] — [1]Institut für Theoretische Physik und Astrophysik, D-24098 Kiel, Germany — [2]Joint Institute for High Tem- peratures RAS, 125412 Moscow, Russia

Using quantum Monte Carlo method [1] we analyze collective excitations (dynamic structure factor $S(q, \omega)$) in a two-component bosonic system in the bilayer geometry. Dipolar bosons from two layers can differ in their mass, effective scattering length and value of the dipole moment oriented perpendicular to the plane of motion. Motion in the transverse direction is controlled by a confining potential provided by an optical lattice. This leads to a system of two coupled quasi-two dimensional layers dominated either by the intra- or inter-layer interactions.

The dispersion law for the out-of-phase and in-phase collective modes during a crossover from weakly to strongly bound inter-layer dimers is studied in detail and compared with the predictions based on the sum rules formalism [2]

[1] A. Filinov and M. Bonitz, Phys. Rev. A 86, 043628 (2012); [2] K.I. Golden, G.J. Kalman, Phys. Rev. E 88, 033107 (2013).

A 8.5 Mon 15:00 BEBEL E34

Quantum tests of the Weak Equivalence Principle in microgravity — •Naceur Gaaloul, Christian Schubert, Wolfgang Ertmer, and Ernst Rasel — Leibniz University of Hanover, Germany

The high precision of atom interferometer-based sensors makes it nowadays an exquisite tool for performing tests of fundamental theories and for practical applications in inertial navigation, geophysics and timekeeping. One timely challenge is to test the weak equivalence principle, a corner stone of General Relativity, by tracking the trajectories of two different masses in free fall. An unprecedented sensitivity is expected when the interferometry time is reaching several seconds thanks to an operation in microgravity. In the talk we present the current study status of proposed European space missions (Q-WEP and STE-QUEST) aiming for a weak equivalence principle test using a differential atom interferometer with Bose-Einstein condensates as a source. The measurement principle will be presented, an overview of the payload design will be given, and the estimated error budget will be discussed.

A 8.6 Mon 15:15 BEBEL E34

Electromagnetically induced transparency in optical lattices — •Khaled Mohamed Almhdi Alghtus and Alejandro Saenz — AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstraße 15, 12489 Berlin, Germany

Electromagnetically induced transparency in ultracold atomic gases trapped in optical lattices should be more efficient than in vapour, since collisions and thus dephasing are reduced. In this work the manipulation of electromagnetically induced transparency in optical lattices by a microwave field coupling the two ground states is discussed. The importance of the relative phases of the optical and microwave fields as well as the light shifts due to the optical-lattice forming laser beams is investigated. It is shown how the microwave field can help to control the group velocity and thus the slowing of the light. Furthermore, it is demonstrated analytically how the additional microwave field can be used to compensate for the light shifts (red-detuned case) caused by the additional lattice-forming beam. In addition, various filling patterns of the atoms over the optical lattice are simulated. The coherence and population decay in various filling patterns are discussed. Finally, we have investigated how the concept of neural networks can be used to classify different patterns of the optical lattice and to simulate the coherence decay for different patterns for optimizing the optical lattice and its filling pattern for an optimal effect of electromagnetically induced transparency.

A 8.7 Mon 15:30 BEBEL E34

Quantum many-body physics of interacting photons — •Sebnem Günes Söyler and Thomas Pohl — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We study stationary light of massive photons emerging in a gas of interacting atoms via electromagnetically induced transparency. Path integral Monte Carlo simulations permit an approximation-free determination of the equilibrium phases of the resulting two-component system composed of photons and strongly interacting spin waves. Using this approach we identify a range of interesting quantum phases for varying coupling strengths between the two components, such as photonic superfluids that develop long-range diagonal order for certain parameters. An experimental realization via strongly interacting Rydberg gases will also be discussed.

A 8.8 Mon 15:45 BEBEL E34

Dissipation as a resource for atomic binding and crystallization — •Mikhail Lemeshko[1], Johannes Otterbach[1], and Hendrik Weimer[2] — [1]Harvard University, Cambridge MA, USA — [2]Leibniz Universität Hannover, Germany

The formation of molecules and supramolecular structures results from bonding by conservative forces acting among electrons and nuclei and giving rise to equilibrium configurations defined by minima of the interaction potential. Here we show that bonding can also occur by the non-conservative forces responsible for interaction-induced coherent population trapping. The bound state arises in a dissipative process and manifests itself as a stationary state at a preordained interatomic distance. Remarkably, such a dissipative bonding is present even when the interactions among the atoms are purely repulsive. The dissipative bound states can be created and studied spectroscopically in present-day experiments with ultracold atoms or molecules and can potentially serve for cooling strongly interacting quantum gases [1].

An extension of this technique to a many-particle system (Bose-Einstein Condensate of Rydberg-dressed atoms) allows to observe long-range ordered crystalline structures emerging due to dissipation [2].

[1] M. Lemeshko, H. Weimer, "Dissipative binding of atoms by non-conservative forces" Nature Communications 4, 2230 (2013)

[2] Johannes Otterbach, Mikhail Lemeshko, "Long-Range Order Induced by Dissipation", arXiv:1308.5905