Q 12: Quantum gases: Bosons, mixtures and spinor gases

Time: Monday 14:00–15:45 Location: UDL HS2002

Q 12.1 Mon 14:00 UDL HS2002

Echo Type Mass Spectroscopy of Impurities Immersed in a Bose Gas — •Tobias Rentrop, Arno Trautmann, Jonas Zeuner, Raphael Scelle, and Markus Oberthaler — Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

We study the impact of a Bose Einstein condensate of sodium atoms on the dynamics of lithium atoms. For this purpose the lithium atoms are confined in a species-selective lattice potential and we investigate the oscillation frequency as a measure of the effective mass. By implementing an echo sequence for the two lowest motional states in the optical lattice, we compensate for the inhomogeneities of the system. Based on this technique, we developed an interferometer type method capable of measuring frequency shifts at the 10^{-4} level. This precision is necessary for detecting the expected small mass changes due to the weak coupling limit of our system. The observed frequency change indicates an effective mass increase of the lithium atoms on the order of a per mille.

Q 12.2 Mon 14:15 UDL HS2002

Compact strongly interacting quantum mixtures for precision atom interferometry — •Katerine Posso-Trujillo, Holger Ahlers, Christian Schubert, Naceur Gaaloul, and Ernst M. Rasel — Institute of Quantum Optics, Leibniz University, Welfengarten 1, 30167 Hanover, Germany

We present a preparation scheme of a binary quantum mixture for performing a high resolution quantum test of the Einstein equivalence principle based on atom interferometers, where coherent wave packets travel up to 10 seconds in free fall. As case study species, the isotopes 87Rb and 85Rb are considered. An exact calculation of the non-linear expansion dynamics of the mixture is performed by solving a system of coupled Gross-Pitaevskii equations contrasted to the results of a scaling approach theory. The latter is generalized for the case of binary mixtures and its relevance is discussed for the regimes of weak and strong interactions. The effects of a common delta-kick cooling stage, computed using experimentally accessible parameters, are analysed and demonstrate the possibility of creating ultra-slow degenerate mixture expansions (below 100 pK temperature equivalent). Leading systematic effects relevant to differential atom interferometry are discussed and mitigation strategies found for the proposed source.

Q 12.3 Mon 14:30 UDL HS2002

Quench dynamics and non-thermal fixed points in a spin-1 spinor Bose-Einstein condensates — •Sebastian Heupts[1,2], Markus Karl[1,2], and Thomas Gasenzer[1,2] — [1]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany

We present a numerical analysis of nonequilibrium dynamics in spin-1 ferromagnetic and antiferromagnetic spinor Bose-Einstein condensates using classical field equations in a statistical approach. The system is driven away from equilibrium by classically unstable initial conditions, resulting in the emergence of topological defects such as spin textures, magnetic domains and domain walls, and spin vortices. This is equivalent to rapid quenches through a second order quantum phase transition, which can be done very well experimentally. We study the time evolution of the system and the excitation spectrum in the context of turbulent scaling properties. The results can be interpreted in terms of nonthermal fixed points and give rise to the possibility to study spin turbulence in experiment without the necessity of detecting topological defects in situ.

Q 12.4 Mon 14:45 UDL HS2002

Thermalization measurements on an ultracold mixture of metastable triplet He and Rb atoms — •Hari P. Mishra, Adonis S. Flores, Wim Vassen, and Steven Knoop — LaserLaB, VU University, Amsterdam, The Netherlands

We have experimentally studied interspecies thermalization in an ultracold mixture of metastable triplet ^{4}He and ^{87}Rb atoms in a quadrupole magnetic trap. This extreme mass-imbalance mixture is interesting for testing the scale invariance of the spectrum of Efimov trimers. Unfortunately, information on the doublet and quartet interaction potentials is scarse and no spectroscopic data is available. Our thermalization measurements, in combination with numerical calculations of the temperature dependent cross section, provide the very first determination of the quartet scattering length. We will discuss its consequence for our cooling scheme to realize an ultracold mixture in an optical dipole trap, required to search for and utilize interspecies Feshbach resonances. Also prospects for an ultracold mixture of metastable ^{3}He and ^{87}Rb are discussed.

Q 12.5 Mon 15:00 UDL HS2002

Superfluid Quantum Turbulence in 2D from Gauge/Gravity Duality — •Andreas Samberg[1,2], Markus Karl[1,2], Thomas Gasenzer[1,2], and Carlo Ewerz[1,2] — [1]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany

We employ the gauge/gravity duality to study the non-equilibrium physics of a strongly interacting superfluid in two dimensions, such as liquid helium or ultracold Bose gases. By mapping the superfluid state to a classical gravitational system in a higher-dimensional black hole spacetime (the so-called 'holographic superconductor'), we get a nonperturbative handle on the quantum dynamics beyond mean-field. This method naturally incorporates the coupling of the superfluid to the thermal normal component. We numerically solve the higher-dimensional equations of motion, starting from a far-from-equilibrium state dual to a regular lattice of vortices. We present results indicating the occurrence of a quasi-stationary turbulent state, paying special attention to vortex–antivortex correlations. We discuss our results in terms of nonthermal fixed points. The kinetic energy spectrum exhibits scaling behavior $E_{\rm kin} \sim k^{-\zeta}$ with an exponent $\zeta \sim -5/3$, the hallmark of Kolmogorov scaling.

Q 12.6 Mon 15:15 UDL HS2002

Tuning Superfluid Phases of Spin-1 Bosons in Cubic Optical Lattice With Linear Zeeman Effect — •Mohamed Mobarak[1] and Axel Pelster[2] — [1]Department of Physics, Freie Universität Berlin, Germany — [2]Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany

We analyze theoretically a spinor Bose gas loaded into a three-dimensional cubic optical lattice. In order to account for different superfluid phases of spin-1 bosons in the presence of an external magnetic field, we follow Refs. [1,2] and work out a Ginzburg-Landau theory for the underlying spin-1 Bose-Hubbard model. In particular at zero temperature, we determine both the Mott and the superfluid phases for the competition between the anti-ferromagnetic interaction and the linear Zeeman effect within the validity range of the Ginzburg-Landau theory. Moreover, we find that the phase transition between the superfluid and Mott insulator phases is of second order and that the transitions between the respective superfluid phases for anti-ferromagnetic interaction can be both of first and second order [3,4].

[1] F.E.A. dos Santos and A. Pelster, Phys. Rev. A **79**, 013614 (2009)

[2] B. Bradlyn, F.E.A. dos Santos, and A. Pelster, Phys. Rev. A **79**, 013615 (2009)

[3] M. Mobarak and A. Pelster, Laser Phys. Lett. **10**, 115501 (2013)

[4] M. Mobarak and A. Pelster, `arXiv:1310.0600`

Q 12.7 Mon 15:30 UDL HS2002

A new renormalization-group approach to superfluid turbulence and non-thermal fixed points — Thomas Gasenzer, •Steven Mathey, and Jan M. Pawlowski — Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany

We investigate stationary scaling solutions of the driven dissipative Gross Pitaevskii equation by means of the functional renormalisation group. The hydrodynamic decomposition of the wave function is exploited to describe the system in terms of the stochastic Burgers equation.

The renormalization group flow equations are closed with a very general, non perturbative, momentum dependent truncation. We write and solve RG fixed point equations for our ansatz which gives access to all the non trivial scaling solution it can support. Our results compare well to the outcome of 1d perturbative calculations. We find another yet unobserved non perturbative fixed point with original scaling exponents.