A 5: Ultra-cold atoms and molecules II (joint session A/MO/Q)

Time: Monday 14:00–16:00 Location: S HS 1 Physik

A 5.1 Mon 14:00 S HS 1 Physik

Spectroscopic studies on bosonic NaK — •Kai K. Voges, Philipp Gersema, Jannis Schnars, Torsten Hartmann, Torben A. Schulze, Alessandro Zenesini, Eberhard Tiemann, and Silke Ospelkaus — Institut für Quantenoptik, Universität Hannover

With their large electric dipole moments and their rich internal level structures heteronuclear polar ground state molecules yield a rich test bed for a variety of dipolar quantum phenomena.

In our experiment, we aim at the creation of ultracold bosonic ensembles of ground state polar ^{23}Na^{39}K molecules by means of Feshbach molecule association and subsequent two-photon transfer to rovibrational ground state polar molecules. This is a challenging task which requires detailed knowledge of the molecular level structure both at atomic threshold and at the bottom of the molecular potential.

In this talk we present our spectroscopic investigations on bosonic ^{23}Na^{39}K molecules. We perform microwave and radio frequency spectroscopy on bound Feshbach states identifying promising candidates for the initial association into shallow-bound states. Furthermore, we perform laser spectroscopy of the electronic excited $B^1\Pi(v = 8)$ and $c^3\Sigma(v = 30)$ coupled states. These data allow us to model the excited state manifold and determine the singlet-triplet mixing between these states. Moreover, we perform dark-resonance spectroscopy locating the two lowest lying rotational states in the molecular ground state potential. Finally, we will report on our progress to combine the different spectroscopic results for the creation of an ensemble of rovibrational ground state polar molecules.

A 5.2 Mon 14:15 S HS 1 Physik

Pair superfluid phases in quasi one dimensional dipolar gases — •Rebecca Kraus[1], Krzysztof Biedroń[2], Jakub Zakrzewski[2,3], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany — [2]Instytut Fizyki imienia Mariana Smoluchowskiego, Uniwersytet Jagielloński, Łojasiewicza 11, 30-048 Kraków, Poland — [3]Mark Kac Complex Systems Research Center, Jagiellonian University, Łojasiewicza 11, 30-348 Kraków, Poland

We consider ultracold dipolar bosons in an optical lattice in a quasi-one dimensional geometry. We focus on the stability of pair superfluidity [1,2] as a function of the dipole interaction strength. We discuss the phases also for different power laws, such as van der waals interaction between Rydberg dressed atoms.

[1] K. Biedroń et al., PRB 97, 245102 (2018) [2] T. Sowiński et al., PRL 108, 115301 (2012)

A 5.3 Mon 14:30 S HS 1 Physik

Dipolar quantum droplets — •Fabian Böttcher, Jan-Niklas Schmidt, Matthias Wenzel, Julian Kluge, Viraatt Sai, Jens Hertkorn, Tim Langen, Arup Bhowmick, Mingyang Guo, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology IQST, Universität Stuttgart

The interplay of the short-range and isotropic contact interaction and the long-range and anisotropic dipolar interaction, allows for many interesting phenomena. In the case of the interactions competing with each other the mean-field contribution can get very small so that beyond mean-field effects start to play an important role and can actually stabilize an otherwise collapsing system. In our experiment with dysprosium atoms we observed a phase-transition between a gas and a liquid, characterized by the formation of self-bound droplets. These droplets show a saturation of the peak density with higher number of atoms like other liquids, even though they are 100 million times less dense than liquid helium droplets. The self-bound character of them opens up the mew perspective of a truly isolated quantum system.

With our experiment we can study a single self-bound droplet and measure the critical atom number for the phase transition between liquid droplet and expanding gas for more than an order of magnitude. For a single droplet we can also observe its anisotropic density distribution in-situ, as well as study the collective excitations. Furthermore the tendency of the system to form self-organized structures opens the possibility to reach a supersolid ground state.

A 5.4 Mon 14:45 S HS 1 Physik

Anisotropic Superfluid Behavior of a Dipolar Bose-Einstein Condensate — •Jan-Niklas Schmidt, Matthias Wenzel, Fabian Böttcher, Tim Langen, Igor Ferrier-Barbut, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology IQST, Universität Stuttgart

Superfluidity still represents a hallmark of quantum physics. Its discovery in liquid helium was one of the first proofs for the influence of quantum effects at the macroscopic scale. The famous Landau criterion connects the maximal velocity for fritionless flow, mainly a transport property of such a superfluid, and its spectrum of elementary excitations. Later various transport measurements could show that also a Bose-Einstein condensate (BEC) features these properties, where the breakdown of superfluid flow can be probed by moving a microscopic impurity through the condensate. In case of a BEC of atoms with strong magnetic dipole-dipole interaction the breakdown of superfluid flow becomes directional, which directly can be seen as a probe of the anisotropic dipolar excitation spectrum.

During this talk we present transport measurements using a dipolar BEC of highly magnetic ^{162}Dy atoms, where we move an attractive laser beam through the condensate and observe an anisotropic superfluid flow. The critical velocity and the above starting heating rate is in excellent agreement with fully numerical simulations of the extended Gross-Pitaevskii equations that mimic our particular system.

A 5.5 Mon 15:00 S HS 1 Physik

Self-bound ultracold Bose mixtures — •Clemens Staudinger[1], Ferran Mazzanti[2], and Robert E. Zillich[1] — [1]Institute for Theoretical Physics, Johannes Kepler University Linz, Austria — [2]Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, Spain

Recent experiments confirmed that fluctuations beyond the mean-field approximation can lead to self-bound liquid droplets of ultradilute binary Bose mixtures at very low temperatures. We study liquid Bose mixtures by using the variational hypernetted-chain Euler–Lagrange method, which accounts for correlations nonperturbatively. For the case of a uniform mixture, as it is found in the center of large droplets at saturation density, we study the conditions for stability against evaporation of one of the components (both chemical potentials need to be negative) and against liquid-gas phase separation, the spinodal instability. We discover that dilute Bose mixtures are stable only in a narrow range near an optimal ratio ρ_1/ρ_2 and in the vicinity of the total energy minimum. Despite the low density, deviations from a universal dependence on the s-wave scattering lengths are significant. We show how our results for uniform Bose mixtures can be extended to finite liquid droplets based on local density approximations.

A 5.6 Mon 15:15 S HS 1 Physik

Bose polaron scenario in an ultracold Fermi-Bose mixture of ^{6}Li and ^{133}Cs — •Eleonora Lippi[1], Binh Tran[1], Manuel Gerken[1], Lauritz Klaus[1], Bing Zhu[1,2], Moritz Drescher[3], Manfred Salmhofer[3], Tilman Enss[3], and Matthias Weidemüller[1,2] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China — [3]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 19, 69120, Heidelberg, Germany

An ultracold Fermi-Bose mixture of ^{6}Li and ^{133}Cs is an appealing playground to investigate the Bose polaron, a quasi-particle describing a single fermionic Li impurity immersed into a Bose-Einstein condensate (BEC) of Cs and dressed by the phononic excitations of the condensate. The well-suited Feshbach resonances at high magnetic field provide a great degree of tunability of intra- and inter-species interactions, enabling us to explore both the repulsive and the attractive regime of the polaron. Due to the large Li-Cs mass ratio, signatures of 3-body Efimov physics in the energy spectrum of the polaron are expected. The observation of different polaron states from the Landau-Pekar polaron to the bubble polaron is also predicted for a Li-Cs mixture [1].

I will discuss how to combine a large BEC of Cs with Li impurities trapped into a microtrap, and our strategy for investigating Bose polaron's properties by means of radio-frequency spectroscopy.

[1] M.Drescher et al., arXiv:1810.11296 (2018)

A 5.7 Mon 15:30 S HS 1 Physik

Exploring Fermi polarons across an orbital Feshbach resonance — •Nelson Darkwah Oppong[1,2], Luis Riegger[1,2], Oscar Bettermann[1,2], Moritz Höfer[1,2], Jesper Levinsen[3], Meera M. Parish[3], Immanuel Bloch[1,2], and Simon Fölling[1,2] — [1]Ludwig-Maximilians-Universität, München, Germany — [2]Max-Planck-Institut für Quantenoptik, Garching, Germany — [3]School of Physics and Astronomy, Monash University, Victoria, Australia

Ultracold atoms are a particularly clean system for probing polaronic states of interacting particles. Fermi polarons in particular have been studied with several realizations, all of which were using alkali atoms. Here, we report on the observation of attractive and repulsive Fermi polarons across the orbital Feshbach resonance (OFR) in a two dimensional gas of ^{173}Yb. This novel type of Feshbach resonance allows tuning the s-wave scattering length of atoms in the $^1S_0$ ground state and the metastable $^3P_0$ state. In our experiment, we prepare a spin-imbalanced Fermi gas for various interaction parameters $\ln(k_F a_{2D})$ in the vicinity of the OFR. We spectroscopically identify two distinct energy branches corresponding to attractive and repulsive Fermi polarons. In addition, we probe the quasiparticle properties, namely the quasiparticle residue and the lifetime of the repulsive polaron. We find good agreement between the experimental results and the predictions from our many-body theory.

A 5.8 Mon 15:45 S HS 1 Physik

Quantum Zeno-based Detection and State Engineering of Ultracold Polar Molecules — •Amit Jamadagni Gangapuram and Hendrik Weimer — Institut für Theoretische Physik, Leibniz Universität Hannover, Hannover, Germany.

We present a toolbox for the controlled manipulation of ultracold polar molecules, consisting of detection of molecules, atom-molecule entanglement and engineering disspative dynamics. Our setup is based on fast chemical reactions between molecules and atoms leading to a quantum zeno based collisional blockade in the system. We discuss the optimization of the relevant parameters as well as the consequences of residual imperfections.