Q 18: Trapping and Cooling of Atoms (joint session Q/A)

Time: Tuesday 11:00–13:00 Location: HS 1221

Invited Talk Q 18.1 Tue 11:00 HS 1221

Continuous lasing and pinning of the dressed cavity resonance with strongly-coupled ^{88}Sr atoms in a ring cavity — •Vera Schäfer — JILA, University of Colorado, Boulder, USA — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

Superradiant lasers are a promising path for realising a narrow-linewidth, high-bandwidth active frequency reference. They shift the phase memory from the optical cavity, which is subject to technical and thermal vibration noise, to an ultra-narrow optical atomic transition of an ensemble of cold atoms trapped inside the cavity. Our previous demonstration of pulsed superradiance on the mHz transition in ^{87}Sr achieved a fractional Allan deviation of $6.7 * 10^{-16}$ at 1s of averaging. Moving towards continuous-wave superradiance promises to further improve the short-term frequency stability by orders of magnitude. A key challenge in realizing a cw superradiant laser is the continuous supply of cold atoms into a cavity, while staying in the collective strong coupling regime.

We demonstrate continuous loading and transport of cold ^{88}Sr atoms inside a ring cavity, after several stages of laser cooling and slowing. We further describe the emergence of zones of collective continuous lasing of the atoms on the 7.5kHz transition, 7x narrower than the cavity linewidth, and pumped by the cooling lasers via inversion of the motional states. The lasing is supported by self-regulation of the number of atoms inside the cavity that pins the dressed cavity frequency to a fixed value over >2MHz of raw applied cavity frequency. In the process up to 80% of the original atoms are expelled from the cavity.

Q 18.2 Tue 11:30 HS 1221

Using multifrequency light for large cold atom traps — •David Johnson, Ben Hopton, Nathan Cooper, and Lucia Hackermüller — University of Nottingham, Nottingham, UK

Magneto-optical trapping (MOT) and Bose-Einstein-Condensates (BECs) are used for a wide range of applications, such as sensors for magnetic or gravitational fields, as well as to test fundamental questions such as Quantum Gravity. Larger atom clouds would allow for more precise sensors and test a larger range of parameters of such theories. One limitation to the size of the trapped cold atom cloud is the range of atom velocities that can be addressed by the trapping beams. By using multiple frequencies each shifted by approximately 5MHz, we expect an increase of the atom loading rate by a factor of 1000 or more, thus leading to trapping 10-100 times more atoms in our MOT. A dark spot MOT can be used to reduce the influence of collisional losses and fully demonstrate the feasibility of our proposal.

Q 18.3 Tue 11:45 HS 1221

Dipole trapping of mercury — •Sascha Heider, Thorsten Groh, and Simon Stellmer — Physikalisches Institut, Universität Bonn, Nußallee 12, 53115 Bonn, Germany

Mercury is the heaviest, non-radioactive laser-coolable element in the periodic table. With seven naturally occuring isotopes and deep UV transitions (185 nm) suitable for high resolution imaging, mercury is a promising candidate for realizing a future multipurpose quantum gas machine.

We already achieved laser cooling of all seven isotopes on the $^1S_0 \to {}^3P_1$ (254 nm) transition to sub-Doppler temperatures and high atom numbers [PRA 105, 033106].

For further cooling we currently deploy a high power optical dipole trap (300 W at 1070 nm) to overcome the very low polarizability.

Q 18.4 Tue 12:00 HS 1221

Towards light scattering experiments in dense dipolar gases — •Ishan Varma, Marvin Proske, Rhutwik Sriranga, and Patrick Windpassinger — Institute of Physics, JGU Mainz

Dysprosium is a fascinating candidate for studying cooperative and collective effects in dense ultra-cold media. With the largest ground state magnetic moment of all elements in the periodic table (10 Bohr-magnetons), it offers a platform to study light scattering in a system where magnetic dipole-dipole interactions (DDI) and light induced correlations are in mutual competition. At sufficiently high atomic densities, the strong magnetic DDI significantly influence the propagation of light within the sample. In particular, we want to look at signatures of collective light scattering phenomena like super- and subradiance.

This talk reports on the progress made in generating dense samples of ultracold dysprosium atoms. We plan to optically transport atoms into a home-built science cell with high optical access. The creation and imaging of dense atomic samples inside the science cell is achieved using high NA custom objectives, designed and assembled in-house. We present the performance characterization and discuss the development of these objectives in our experimental system. Further, an outlook is given on future measurements exploring collective and cooperative effects in the generated sample.

Q 18.5 Tue 12:15 HS 1221

Report on the construction of a new Erbium-Lithium machine — •Alexandre De Martino, Florian Kiesel, Kirill Karpov, Jonas Auch, and Christian Gross — Eberhard Karls Universität Tübingen, Physikalisches Institut, AG Groß, Auf der Morgenstelle 14, 72076 Tübingen

Fermionic gases are notoriously difficult to cool down below 10% of the Fermi temperature with usual methods. Pushing the temperature limit and producing colder gases is becoming essential for the study of strongly correlated systems. Sympathetic cooling with a classical gas as an entropy reservoir may provide a new direction to overcome the current limit.

Here we report on the ongoing development of a new Erbium-Lithium machine, whose purpose is to optimize the cooling of an ultracold Lithium gas with an Erbium reservoir. This mixture has several promising features, that have not yet been utilized for sympathetic cooling in other quantum mixtures.

Q 18.6 Tue 12:30 HS 1221

ORKA - Towards a cavity enhanced Optical Dipole Trap for evaporative cooling of Rb87 in microgravity — •Jan Eric Stiehler, Marius Prinz, Marian Woltmann, and Sven Herrmann — Center of Applied Space Technology and Microgravity (ZARM), University of Bremen, Germany

Evaporative cooling in optical traps is a common method to prepare ultra-cold quantum gases and generate Bose Einstein condensates (BEC). This usually comes at the prize of an increased power budget for the trapping laser. For setups that require to be energy efficient e.g. in space, magnetic chip traps are thus often preferred. However, these also come with certain limitations and lack some of the benefits of all-optical trapping and cooling. As an alternative we are investigating the use of a resonantly enhanced optical dipole trap for Rb87 to mitigate the power needs of all-optical evaporative cooling. We plan to employ a bow-tie cavity for evaporative cooling to a BEC, to be used as a matterwave source for interferometry in free fall experiments at the the Bremen Gravitower Pro facility. In this talk we will discuss the trade-off for our trapping scheme and present the resulting experiment design as well as simulation results for the bow-tie cavity trap. The ORKA project is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Climate Action under grant number DLR 50 WM 2267.

Q 18.7 Tue 12:45 HS 1221

Confinement Induced Resonances in Spherical Shell Traps — •C. Moritz Carmesin[1] and Maxim A. Efremov[2,1] — [1]Institute of Quantum Physics and Center for Integrated Quantum Science and Technology (IQST), Universität Ulm, 89081 Ulm, Germany — [2]German Aerospace Center (DLR), Institute of Quantum Technologies, 89081 Ulm, Germany

We have computed exactly the energy spectrum and corresponding wave functions of two bosonic particles, which are confined in a spherically symmetric shell-shaped trap of the radius r_0 and interact with each other via a three-dimensional zero-range potential characterized by the *s*-wave scattering length a_0. Confinement induced resonances (CIRs) are found to occur at certain values of r_0 and a_0 as avoided crossings between the bound (molecular) and trap (non-molecular) states, as well as between two trap states. The found CIRs originate entirely from the strong coupling of the relative and center-of-mass motions of the two particles. By working close to a CIR, that is at a certain shell radius and a given scattering length, these results offer a new way to increase the atom-atom interaction and even to drive the formation of molecules in the shell-shaped atomic gas.