5th Institute of Physics - Stuttgart University

Tue, 2015-04-28 11:57 - Mattia Giardini [1] **Website:** http://www.pi5.uni-stuttgart.de/en/ [2]

Research Type: Experiment

http://www.pi5.uni-stuttgart.de/img/dashed_line.gif) 0% 100% repeat-x rgb(255, 255, 255);"> Dipolar Quantumgases [3]

In this project we experimentally investigate the dipole-dipole interactions in Bose-Einstein condensates (BECs). Even though an atomic Bose-Einstein-Condensate (BEC) is a very dilute system, the most fascinating experimental results arise from the weak interactions between the particles. In most experiments the dominating interaction in a BEC is the isotropic and short-range contact interaction that can be characterized by the s-wave scattering length a. Magnitude and sign of a can be modified using Feshbach resonances. Tuning of the interaction results in the spectacular observation of collapsing condensates ("Bosenova") and the formation of ultra-cold molecular gases out of a BEC. Due to its long-range character and its anisotropic nature the dipole-dipole interaction in a BEC has generated significant theoretical interest. New interesting phenomena like novel quantum phase transitions, dipolar order and spin tunnelling in the condensate have been predicted. New questions concerning stability and shape of such a condensate arise.

http://www.pi5.uni-stuttgart.de/img/dashed_line.gif) 0% 100% repeat-x rgb(255, 255, 255);"> Strongly interacting Rydberg gases [4]

Rydberg atoms are highly excited atoms with one valence electron of principal quantum number n>>1. Because of their huge size of the order n2a0 they are very susceptible to external electric fields and interact strongly. These unusually strong interactions lead to a blockade of excitation in the so called blockade radius of the Rydberg atoms. If the system is driven coherently a single excitation can be shared by several atoms within the blockade radius, forming a 'super atom', a collective quantum state. In this project Rydberg excitation of a magnetically trapped dense cloud is performed. Goals of this experiment, besides the study of interactions between Rydberg atoms (dipole-dipole and van der Waals interaction) and the already shown excitation of Rydberg atoms in a Bose-Einstein condensate, are studies of the coherent collective quantum states. Furthermore a novel type of molecular bond can be formed by Rydberg atoms. After the first observation of these molecular states and further studies of this new binding mechanism, coherent control of the molecules is experimentally investigated in this project.

http://www.pi5.uni-stuttgart.de/img/dashed_line.gif) 0% 100% repeat-x rgb(255, 255, 255);"> Novel sources of ultra cold matter [5]

Quantum gases represent powerful tools for the study of many body phenomena and for precision measurements. For many species, however, standard laser cooling mechanisms are not applicable due to the lack of a closed cycling transition. Especially for atoms with a rich level structure and for molecules laser cooling is not (or hardly) feasible.

We are using a new approach to reach degeneracy: an optical dipole trap (ODT) is continously loaded from a guided atomic beam with a mechanism that can be compared to a diode for atoms. An

ODT is therefore placed within an atomic beam. A state dependent potential barrier superimposed to the trap removes the directed kinetic energy from the atoms, while they are traveling through the ODT's focus. This dissipative mechanism is in principle a single photon process, and not depending on a closed cycling transition. Loading the trap until it reches the collisionally dense regime then allows further cooling by evaporation.

With this method, we can produce a BEC with chromium atoms within less than 5s. While we do use laser cooling to generate our beam of chromium atoms, there are methods to generate intense beams with molecules that have recently been established and which are not based on cycling transitions.

http://www.pi5.uni-stuttgart.de/img/dashed_line.gif) 0% 100% repeat-x rgb(255, 255, 255);"> µ-cell [6]

The strong interaction among Rydberg states leads to a blockade mechanism which only allows for one excitation into a Rydberg state within the blockade volume. This effect has been shown e.g. by our Rydberg experiments with ultracold atoms.

The key idea is to confine thermal vapors of Alkalis in spectroscopy cells smaller than the blockade radius, which is on the order of a few microns. By this only one Rydberg excitation is allowed within in one cell, or several close by cells. This system opens the way to a large nonlinearity on the single photon level with many possible applications in quantum information technology and quantum optics.

http://www.pi5.uni-stuttgart.de/img/dashed_line.gif) 0% 100% repeat-x rgb(255, 255, 255);"> Rydberg Quantum Optics [7]

Leader: Prof. Dr. Tilman Pfau

Location

Universität Stuttgart Pfaffenwaldring 57
Stuttgart 70569 Germany
48° 44' 42.4572" N, 9° 6' 12.7188" E
See map: Google Maps [8]

- RySQ [9]

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