# Q 22: Ultrakalte Plasmen und Rydberg-Gase (gemeinsam mit A)

Zeit: Dienstag 10:30–12:15 Raum: 5M

**Hauptvortrag** Q 22.1 Di 10:30 5M

**Rydberg atom and molecule optics** — •Frederic Merkt, Edward Vliegen, and Stephen Hogan — ETH Zurich, Zurich, Switzerland

Recent experiment are reviewed in which the velocity distributions of Rydberg atoms and molecules have been influenced by the use of inhomogeneous fields. The experiments rely on the very large dipole moments exhibited by Rydberg Stark states and the large forces that can be applied on the particles by inhomogeneous electric fields. Typical experiments rely on the photoexcitation of cold atoms and molecules in skimmed supersonic beams to Rydberg Stark states. When propagating through regions of space in which inhomogeneous electric fields are applied, the particles are subject to strong forces [1]. Carefully designed electrode configurations enable the application of very large forces. By optimizing the time dependence of the applied electric fields the forces applied on the atoms can be adapted to the instantaneous positions of the particles [2,3]. Based on these principles, we have realised several devices such as Rydberg atom deflectors [1], accelerators and decelerators [1-4], a Rydberg atom mirror [5], and two-dimensional and three-dimensional traps for Rydberg atoms and molecules.

[1] S. R. Procter, Y. Yamakita, F. Merkt and T. P. Softley, Chem. Phys. Lett. 374, 667 (2003) [2] E. Vliegen, H.J. Woerner, T.P. Softley and F. Merkt, Phys. Rev. Lett. 92, 033005 (2004) [3] E. Vliegen and F. Merkt, J. Phys. B 38, 1623 (2005) [4] E. Vliegen and F. Merkt, J. Phys. B 39, L241 (2006) [5] E. Vliegen and F. Merkt, Phys. Rev. Lett. 97, 033002 (2006)

**Fachvortrag** Q 22.2 Di 11:00 5M

**Rydberg excitation in the strong blockade regime: from thermal cloud to BEC** — •Vera Bendkowsky[1], Rolf Heidemann[1], Ulrich Raitzsch[1], Björn Butscher[1], Helmar Bender[1], Robert Löw[1], Luis Santos[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart — [2]Institut für Theoretische Physik, Universität Hannover, Appelstraße 2, 30167 Hannover

The van der Waals interaction of Rydberg atoms can - depending on the atomic density and the excitation strength - lead to a supression of Rydberg excitation in a cloud of ground state atoms. In this blockade regime the atomic sample can be considered as consisting of many blockade spheres with $N$ ground state atoms within a sphere but only one excited Rydberg atom.

In our experiments we excite magnetically trapped Rubidium atoms at temperatures between a few $\mu$K and BEC to the 43S state. In the thermal cloud we observe saturation in the Rydberg excitation for a large range of densities and Rabi frequencies $\Omega_0$. As expected for coherent collective excitation of any mesoscopic system the initial excitation rate is proportional to $\sqrt{N}\Omega_0$. The scaling of the saturation value is investigated with respect to $N$ and $\Omega_0$.

Furthermore we present first results on Rydberg excitation in a BEC. The measurements show a clear signature of Rydberg excitation within the BEC. The results are compared with a mean field calculation for the quantum dynamics above and below $T_c$.

Q 22.3 Di 11:30 5M

**Observation of Rabi cycles and coupling to continuum states in the excitation of a mesoscopic cloud of cold atoms to Rydberg levels** — •Markus Reetz-Lamour, Thomas Amthor, Johannes Deiglmayr, Sebastian Westermann, Janne Denskat, and Matthias Weidemüler — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg

Ultracold Rydberg gases are a possible candidate for quantum information processing combining the coherence properties of ground state atoms with strong Rydberg-Rydberg interaction for fast quantum gates [1]. While the coherent character of Rydberg-Rydberg interaction has been confirmed in a number of experiments [2], the realization of q-bits itself turned out to be rather challenging.

We will present the experimental ingredients to drive Rabi cycles between the electronic ground states and Rydberg states in a mesoscopic cloud of $\sim$100 laser-cooled $^{87}$Rb atoms, which is the essential ingredient for constructing qbits with Rydberg atoms. We will also show how this coherent excitation can be used to study coupling to a quasi-continuous large subset of Rydberg states. This leads to effects very similar to Fano resonances.

[1] Jaksch *et al.*, PRL **85**, 2208 (2000), Lukin *et al.*, PRL **87**, 037901 (2001)
[2] *E.g.* Anderson *et al.*, PRA **65**, 063404 (2002), Westermann *et al.*, EPJ D **40**, 37 (2006)

Q 22.4 Di 11:45 5M

**Simulating the dynamics of strongly coupled many-particle plasmas at low temperatures.** — •Michael Bussmann[1], Ulrich Schramm[2], and Dietrich Habs[1] — [1]Department f. Physik, Ludwig-Maximilians-Universität Muenchen, Am Coulombwall 1, 85748 Garching — [2]Forschungszentrum Dresden Rossendorf, Bautzner Landstraße 128, 01328 Dresden

The dynamics of strongly coupled plasmas at mK temperatures are studied for the special case of stopping highly charged ions in a laser cooled plasma of $N = 10^5$ $^{24}Mg^+$ ions [1].
Using a parallel simulation code the stopping process is studied with respect to stopping times, plasma stability and recooling efficency [2]. It is shown that the proposed cooling scheme is feasible for cooling highly charged rare ions to mK temperatures without suffering from ion loss due to charge exchange.
In the outlook we present examples of simulations of strongly coupled plasmas in beam and trap physics illustrating the capabilities of the simulation with regard to investigating many-particle systems at low temperatures.

[1] M. Bussmann, U. Schramm, V. Kolhinen, J. Szerypo, D. Habs, *Int. J. of Mass Spectrometry* **251** (2006) 179-189
[2] M. Bussmann, U. Schramm, D. Habs, *AIP Conference Proceedings* **862** (2006), 221-231

Q 22.5 Di 12:00 5M

**Ultracold negative ions** — •Jan Meier — Max-Planck-Institut für Kernphysik, Postfach 103980, 69029

Currently no technique exists which allows the cooling of negative ions to a temperature lower than that of the surrounding trap. Laser cooling of negative osmium ions holds the prospect of achieving temperatures well below 1 mK. Cooling antiprotons with this technique might open the door to forming antihydrogen at ultra-cold temperatures, thus allowing precision antimatter studies.