MO 1: Ultrakalte Moleküle (mit Q)

Zeit: Montag 10:45–12:15 Raum: VMP 8 HS

MO 1.1 Mo 10:45 VMP 8 HS

Two-photon coherent control of femtosecond photoassociation — •Mamadou Ndong[1], Ronnie Kosloff[2], and Christiane P. Koch[1] — [1]Freie Universität Berlin, Institut für Theoretische Physik, Arnimallee 14, 14195 Berlin — [2]Hebrew University, Dept. of Physical Chemistry, Jerusalem 91904, Israel

Photoassociation with short laser pulses has been proposed as a technique to create ultracold ground state molecules. A broad-band excitation seems the natural choice to drive the series of excitation and deexcitation steps required to form a molecule in its vibronic ground state from two scattering atoms. However, one of the main obstacles with broad-band excitations is to eliminate the atomic excitation which hampered first attempts at femtosecond photoassociation. To overcome the ostensible conflict of driving a narrow transition by a broad-band laser, we propose a two-photon photoassociation scheme. When the excitation is carried out by more than one photon, different pathways in the field can be interfered constructively or destructively. Using the idea of rational phase shaping in two-photon transitions, we derive analytical solutions to suppress atomic transitions in both the weak-field and strong-field regime. Two-photon excitation may thus pave the way toward coherent control of photoassociation. We explore the possibility of two-photon femtosecond photoassociation for alkali and alkaline-earth metal dimers and present a detailed study for the example of calcium.

MO 1.2 Mo 11:00 VMP 8 HS

Heteronuclear molecules in an ultracold Bose-Fermi Mixture — •Oliver Topic, Manuel Scherer, Thorsten Henninger, Carsten Klempt, Eberhard Tiemann, Wolfgang Ertmer, and Jan Arlt — Institut für Quantenoptik, Leibniz Universität Hannover, Germany

The prospect of investigating quantum degenerate molecules with a large dipole moment has driven the field of molecular physics for the past decade. The use of Feshbach resonances now allows for precise control of the interactions in heteronuclear mixtures of two atomic species and provides a new path towards such molecular ensembles.

Within our experiments, bosonic 87Rb atoms are used to cool an ensemble of fermionic 40K atoms to joint quantum degeneracy. This mixture provides the starting point for the detailed analysis and manipulation of the interactions. Applying a homogeneous magnetic field up to 700G allows for the investigation of heteronuclear Feshbach resonances in this mixture. We have been able to observe 28 resonances in ten different spin combinations. Together with results from molecular spectroscopy, this allowed for a large improvement of the interaction model. One of the observed resonances is used for the production of weakly bound heteronuclear Feshbach molecules. We report on a precise characterization of the production efficiency of ultracold Feshbach molecules and its dependence on critical parameters such as temperature and binding energy. Our analysis provides the first full theoretical understanding of this production efficiency and thus paves the way towards the optimised production of deeply bound molecular ensembles.

MO 1.3 Mo 11:15 VMP 8 HS

Preparation of HD^+-Ions in the Ro-vibrational Ground State — •Tobias Schneider, Bernhard Roth, Hannes Duncker, Michael Hansen, Sergey Vasilyev, Ingo Ernsting, and Stephan Schiller — Institut für Experimentalphysik, Universität Düsseldorf, Universitätsstr.1, 40225 Düsseldorf

Being the most simple heteronuclear molecule, the HD^+ molecular ion is an ideal model system for testing the predictions of ab-initio theoretical molecular structure calculations using high precision laser spectroscopy. Two interesting perspectives are improved tests of QED effects in molecules and an alternative determination of the electron to proton mass ration m_e/m_p.

One important prerequisite for high precision spectroscopic measurements is the ability to control the translational as well as internal degrees of freedom of the molecules. For molecular ions stored in an ion trap the motion of the molecules can be cooled via sympathetic cooling with laser cooled atomic ions. Cooling of the internal degrees of freedom is more difficult since the sympathetic cooling does not affect the internal degrees of freedom and in non-cryogenic environments interaction with black body radiation will distribute the molecular population over several ro-vibrational states.

For HD^+ we developed an optical pumping scheme that allows to prepare most of the molecular ions in the ro-vibrational ground state. We present first experimental results.

MO 1.4 Mo 11:30 VMP 8 HS

Formation of dipolar molecules in the absolute ground-state — •Johannes Deiglmayr[1,2], Anna Grochola[1], Marc Repp[3], Olivier Dulieu[2], Roland Wester[1], and Matthias Weidemüller[3] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg — [2]Laboratoire Aimé Cotton, CNRS, Orsay, France — [3]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg

Dipolar molecules in the absolute ground state are promising candidates for the exploration of quantum phases in dipolar gases, the control of ultracold chemical reaction, and a wide range of further systems [1]. In this talk we will report on the formation of ultracold LiCs molecules in the rovibrational ground state $X^1\Sigma^+$,v''=0,J''=0 [2] using photoassociation (PA). The formed molecules are detected in a setup combining resonant-enhanced multi-photon ionization and a high resolution time-of-flight mass spectrometer. Additionally, we employ depletion spectroscopy to determine the rotational state of the formed molecules and to measure the dipole moment of the ground state molecules by Stark spectroscopy. Combining the results of PA and depletion spectroscopy, we also improve the value of the dissociation energy for the $X^1\Sigma^+$ ground state.

[1] O. Dulieu, M. Raoult, and E. Tiemann, E., Introductory review, Special Issue on cold molecules, J. Phys. B **39**, (2006)
[2] J. Deiglmayr *et al.*, PRL **101**, 133004 (2008)

MO 1.5 Mo 11:45 VMP 8 HS

Ultracold Heteronuclear Fermi-Fermi Molecules — •Arne-Christian Voigt[1,2], Matthias Taglieber[1,2], Louis Costa[1,2], Takatoshi Aoki[1,2], Wolfgang Wieser[1,2], Theodor W. Hänsch[1,2], and Kai Dieckmann[1,2] — [1]Department für Physik der Ludwig-Maximilians-Universität, Schellingstraße 4, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

Spin mixtures of quantum-degenerate fermionic gases exhibit long lifetimes in the strongly-interacting regime near a Feshbach resonance. This has opened the door for numerous key experiments like the creation of Fermi-Fermi molecules, the realization of molecular BEC, the observation of a pairing gap and of superfluidity in a fermionic gas in the BEC-BCS cross-over region near a Feshbach resonance.

We present the production of ^{6}Li-^{40}K heteronuclear molecules based on our experimental platform for the production of a two-species mixture of quantum-degenerate Fermi gases [1]. We studied two s-wave Feshbach resonances between lithium and potassium at 155 G and 168 G. By magnetic field sweeps we created about 4×10^4 ^{6}Li-^{40}K molecules at conversion efficiencies of up to 50 % [2]. With a Stern-Gerlach purification technique we are able to image molecules and atoms spatially separated from each other. We show an increased molecule lifetime close to resonance of more than 100 ms in the molecule-atom mixture.

[1] M. Taglieber *et al.*, Phys. Rev. Lett. **100**, 010401 (2008).
[2] A.-C. Voigt *et al.*, accepted for publication in Phys. Rev. Lett.

MO 1.6 Mo 12:00 VMP 8 HS

Observation of a resonant exchange reaction in an ultracold mixture of cesium atoms and dimers — •Martin Berninger[1], Francesca Ferlaino[1], Steven Knoop[1], Walter Harm[1], Michael Mark[1,2], Hanns-Christoph Nägerl[1], and Rudolf Grimm[1,3] — [1]Institut für Experimentalphysik, Universität Innbruck, Austria — [2]Swinburne University of Technology, Melbourne, Australia — [3]Institut für Quantenoptik und Quanteninformation, Innsbruck, Austria

An ultracold atomic gas of cesium is a versatile system to study few-body phenomena because of the extreme tunability of its scattering length. We have studied interactions in an optically trapped mixture of Feshbach molecules with atoms, realized in a Cs gas at nanokelvin temperatures. We start with a sample of atoms in the lowest hyperfine state A and produce molecules AA by means of Feshbach associa-

tion. Then we transfer the remaining atoms A to a hyperfine state B that is distinct from that of the Feshbach molecule's constituents. We study the exchange reaction B + AA → A + AB, which is resonantly enhanced when the binding energies of AA and AB are equal. The reaction rate is prominent and magnetically tunable, thus showing all properties of controllable ultracold chemistry.