MS 8: Ion Trap and FT-ICR-MS, Molecules, Clusters and Reactions

Time: Thursday 14:00–16:15 Location: V57.06

Invited Talk MS 8.1 Thu 14:00 V57.06

Structure and dynamics of finite Fermi systems: simple metal clusters and fullerenes — •Bernd v. Issendorff — Physikalisches Institut, Universität Freiburg, 79104 Freiburg

Of all metallic systems sodium clusters are the ones which are closest to the ideal case of a finite free electron gas. Their electronic density of states is strongly discretized and shows a clear similarity with the electron shell structure of a spherical free electron system, although with some perturbation caused by the usually nonspherical outer shape and the internal atomic structure of the clusters. Recently we have shown by angular resolved photoelectron spectroscopy that in spherical sodium clusters these perturbed electron states still exhibit well defined angular momentum eigenstate character. Here similar results on strongly spheroidally deformed clusters will be presented, which show that even in such cases the angular momentum eigenstate character is preserved. In fact the deformation just lifts the degeneracy of the m_l-substates of a given l-state and causes a mixing between certain states which follows a strict selection rule. Fullerenes with their delocalized valence electron system are well suited for the study of electron dynamics due to their high stability. Time-resolved photoelectron spectroscopy has been applied to gas phase C_{60} anions of controlled temperature. The results show a strong temperature dependence of the relaxation time of the final (and slowest) process in the chain of relaxation processes of the excited excess electron, the $t_{1g} \rightarrow t_{1u}$ transition, which can be seen as a textbook example of the vibrational excitation dependence of a radiationless transition.

Invited Talk MS 8.2 Thu 14:30 V57.06

Light induced reactions (LIR) in a cold 22-pole ion trap — Oskar Asvany, Sandra Brünken, and •Stephan Schlemmer — I. Physikalisches Institut, Universität zu Köln

Ion molecule reactions play an important role in astrophysics and other plasma environments like planetary atmospheres. They are studied in a variable temperature 22-pole ion trap where the temperature dependence of the rate coefficient and thus related activation energies are determined. Reactions with competing product channels are of particular interest because the outcome often strongly depends on the internal states of the reaction partners. In the experiments described vibrational and/or rotational levels of the stored ions are excited by IR or FIR photons. The increase or decrease of the number of product ions monitored by mass spectrometry as a function of the excitation wavelength results in a very sensitive method of action spectroscopy of the parent ions. Examples include protonated hydrogen, H_3^+, the most abundant molecular ion in space, the very floppy CH_5^+ molecule or a radical like CH_2D^+. Experiments at low temperatures lead to simplified spectra and to significant changes in reactivity based on the population of particular states, an effect with significant consequences on the molecular composition of the interstellar medium.

MS 8.3 Thu 15:00 V57.06

Electrostatic ion beam traps: self-bunching, intrabeam scattering, and RF-bunching — •Michael Froese[1], Manfred Grieser[1], Oded Heber[2], Michael Lange[1], Felix Laux[1], Sebastian Menk[1], Roland Repnow[1], Yoni Toker[2], Robert von Hahn[1], Andreas Wolf[1], and Klaus Blaum[1] — [1]Max Planck Institute for Nuclear Physics, 69117 Heidelberg — [2]Weizmann Institute of Science, Rehovot 76100, Israel

The Cryogenic Trap for Fast ion beams (CTF) has been used to investigate the properties of ion bunches in electrostatic ion beam traps (EIBTs). The main ion loss mechanism in these traps (collisional detachment) has been made negligible via our high vacuum levels. For the self-bunching trapping mode achievable with EIBTs, the longitudinal ion bunch density distribution has been measured by photo-detaching aluminum dimer anions, which also revealed the presence of a DC ion beam component co-existing with the oscillating bunch. Stable coherent bunch observation in self-bunching mode was extended from 100 ms in room-temperature EIBTs to times as long as 12 s using N_2^+ and Al_2^- with kinetic energies of 6-7.1 keV. The decay of the bunch signal amplitude was observed to be intensity dependent. A model employing intrabeam scattering as well as the expansion of the bunch with time is found to well reproduce the data. This model was also found to reproduce the decay of the bunch signal when RF bunching was applied in agreement with the newly developed EIBT bunch dynamics. These bunches were observed for 600 s placing correspondingly small upper limits on all other EIBT losses.

MS 8.4 Thu 15:15 V57.06

Electron auto-detachment of excited SF_6^- — •Sebastian Menk[1], Klaus Blaum[1], Swarup Das[2], Michael Froese[1], Michael Lange[1], Manas Mukherjee[2], Robert von Hahn[1], Dirk Schwalm[1,3], Robert von Hahn[1], and Andreas Wolf[1] — [1]MPI für Kernphysik, 69117 Heidelberg — [2]Raman Center for AMO Science, IACS, Kolkata 700 032 — [3]Weizmann Institute of Science, Rehovot, 76100, Israel

Electron auto-detachment of excited SF_6^- has been investigated using the Heidelberg cryogenic electrostatic ion beam trap (CTF), where ions can be confined as a beam at keV energies and a time-dependent decay signal is gained by detecting neutralized fragments which escape from the trapping region. The cryogenic conditions provide extremely high vacuum and accordingly low background rates. Hence, they offer the possibility to observe this decay, in principle, over minutes. For the initial auto-detachment stemming from the SF_6^- excitation in the ion source, we followed its rate until it naturally vanished at ∼100 ms after ion injection. This enabled us to observe for the first time its fall-off from the previously seen power-law behavior. By detailed modeling of the vibrational auto-detachment, this fall-off is found to reflect the detachment threshold and the rotational excitation, with the power-law separately representing the vibrational excitation in the ion source. Corresponding excitation temperatures could be inferred. Over the longer storage time scale uniquely accessible at the CTF, studies of the same process following laser excitation are in preparation.

MS 8.5 Thu 15:30 V57.06

Buffer-gas cooling in a linear radiofrequency quadrupole trap at the CTF — •Christian Breitenfeldt[1], Klaus Blaum[2], Mike Froese[2], Michael Lange[2], Gerrit Marx[1], Sebastian Menk[2], Birgit Schabinger[1], and Lutz Schweikhard[1] — [1]Institut für Physik, Ernst-Moritz-Arndt Univ., 17489 Greifswald, Germany — [2]Max-Plank-Institut für Kernphysik (MPIK), 69117 Heidelberg, Germany

The Cryogenic Trap for Fast ion beams (CTF) is an Electrostatic Ion Beam Trap (EIBT) setup investigating the decay of anions with complex multi-body internal structure at cryogenic temperatures, located at the MPIK in Heidelberg. Recent measurements showed a strong influence of the rotational and vibrational temperatures in the decay of SF_6^-. For more detailed studies using, e.g. laser excitation from well defined initial states, the injection of pre-cooled molecular ions and clusters into the CTF will be of great advantage. Hence, we plan to install a linear RadioFrequency Quadrupole (RFQ) trap to store the hot ions from the source and cool them via buffer gas before their injection into the EIBT. Internal pre-cooling of ions in this buffer-gas RFQ trap can be much faster than in the EIBT. In addition, the implementation of a linear RFQ trap will allow a more effective use of the ions produced by the source. As we typically employ microsecond long pulses, which are stored for several seconds, all other ions are currently lost. By the use of the linear RFQ trap, however, it will be possible to accumulate ions throughout most of the injection cycle, vastly improving the sensitivity and the number of different species accessible.

MS 8.6 Thu 15:45 V57.06

One- and two-pulse quadrupolar excitation schemes of the ion motion in a Penning trap investigated with FT-ICR detection — •Michael Heck[1], Klaus Blaum[1], R.Burcu Cakirli[1,2], Hendrik Golzke[1,3], Martin Kretzschmar[4], Gerrit Marx[5], Lutz Schweikhard[6], Stefan Stahl[7], and Marta Ubieto-Diaz[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Department of Physics, University of Istanbul, Istanbul, Turkey — [3]Karlsruher Institut für Technologie, Karlsruhe, Germany — [4]Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany — [5]Institute of Physics, Ernst-Moritz-Arndt-University Greifswald, 17487 Greifswald, Germany — [6]Universidad de Granada, 18071, Granada, Spain — [7]Stahl-Electronics, Kellerweg 23, 67582 Mettenheim, Germany

Penning traps are widely used as storage devices for charged particles in the fields of analytical and precision mass spectrometry. The coupling of the radial motional modes is achieved by using azimuthal quadrupolar radio frequency (rf) fields. In this work we studied the interconversion of radial modes by applying one- and two-pulse (Ramsey) quadrupolar rf-fields. Dipolar-detection of the Fourier transform ion cyclotron resonance (FT-ICR) signal at the modified cyclotron frequency has been studied as a function of the interaction parameters such as excitation frequency, amplitude and duration and is compared with the theoretical results.

MS 8.7 Thu 16:00 V57.06

Broad-band detection and mass comparison between lithium ions by FT-ICR MS — •Hendrik Golzke[1,2], Klaus Blaum[1], R. Burcu Cakirli[1,3], Michael Heck[1], Daniel Rodriguez[4], Lutz Schweikhard[5], Stefan Stahl[6], and Marta Ubieto-Diaz[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Institut für Experimentelle Kernphysik, Karlsruher Institut für Technologie, Karlsruhe, Germany — [3]Department of Physics, University of Istanbul, Istanbul, Turkey — [4]Departamento de Física Atómica Molecular y Nuclear, Universidad de Granada, Granada, Spain — [5]Institute of Physics, Ernst-Moritz-Arndt-University Greifswald, Greifswald, Germany — [6]Stahl Electronics, Kellerweg 23, 67528 Mettenheim, Germany

Penning traps are widely used as storage devices for charged particles. With such a trap a mass-spectrometry system for the KArlsruhe TRItium Neutrino (KATRIN) experiment has been developed and characterized at the Max-Planck-Institute for Nuclear Physics in Heidelberg. A broad-band non-destructive Fourier Transform Ion Cyclotron Resonance (FT-ICR) method which is able to record simultaneously the eigenfrequencies of different stored particles over a wide range is used. In this talk the dipolar and quadrupolar detection technique and a recent mass comparison between $^{6}Li^{+}$ and $^{7}Li^{+}$ will be presented.