A 15: Precision spectroscopy of atoms and ions III (with Q)

Time: Tuesday 11:00–12:30 Location: B 305

Invited Talk A 15.1 Tue 11:00 B 305

X-ray laser spectroscopy with trapped highly charged ions — •Sven Bernitt — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The X-ray spectra of many astrophysical objects, as observed by X-ray observatories like Chandra and XMM-Newton, are dominated by emission lines of highly charged ions. However, even today's most sophisticated spectral models only poorly fit certain prominent spectral features. For this reason, precise laboratory measurements of astrophysically relevant transition wavelengths and intensities are needed to be able to interpret astronomical observations.

Laser spectroscopy is a remarkably successful experimental method. However, the X-ray wavelength regime has not been accessible due to the lack of appropriate lasers, until in recent years free-electron lasers have become available. In the experiments presented, an electron beam ion trap was used to provide a target of trapped highly charged ions, interacting with femtosecond X-ray pulses from the Linac Coherent Light Source free-electron laser. This introduced the techniques of laser spectroscopy into the 1 keV spectral range, allowing to directly address photonic excitations in highly charged ions.

Results of an experiment, potentially resolving a continuing controversy about the relative intensity ratio of two bright lines in the Fe XVII spectrum, will be presented, as well as new results and applications.

A 15.2 Tue 11:30 B 305

High-precision X-ray spectroscopy of highly charged ions with microcalorimeters — •Saskia Kraft-Bermuth[1], Victor Andrianov[2,3], Alexander Bleile[2], Artur Echler[2], Peter Egelhof[2], Patrick Grabitz[2], Stoyanka Ilieva[2], Caroline Kilbourne[4], Oleg Kiselev[2], Dan McCammon[5], Jan Meier[2], and Pascal Scholz[1] — [1]Institut f. Atomphysik, Justus-Liebig-Universität, Gießen, Germany — [2]Helmholtzzentrum f. Schwerionenforschung, Darmstadt, Germany — [3]Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, Russia — [4]NASA/Goddard SFC, Greenbelt, USA — [5]Dept. Physics, University of Wisconsin, Madison, USA

The precise determination of the energy of the Lyman-α lines in hydrogen-like heavy ions provides a sensitive test of quantum electrodynamics in very strong Coulomb fields. In 2010, a test array of 8 silicon thermistors with Sn and Pb absorbers was used in the first measurement of the Lyman-α energies of lead ions Pb^{81+} with a microcalorimeter at the Experimental Storage Ring (ESR) at GSI. The experimental result agreed well with the theoretical predictions. The overall uncertainty amounted to 26 eV. In 2012, a larger array of 32 silicon thermistors with Sn absorbers and an improved energy resolution was applied to measure the Lyman-α energies of gold ions Au^{78+}. The systematic error of the measurement was reduced by using a new calibration source and an improved beam diagnostics. This contribution will present the results of this experiment. Perspectives for new applications at GSI as well as at the FAIR facility will be presented.

A 15.3 Tue 11:45 B 305

The g factor of lithiumlike silicon $^{28}Si^{11+}$ — •Anke Wagner[1], Sven Sturm[1,2], Florian Köhler[3], Dmitry A. Glazov[4,5], Andrey V. Volotka[4,5], Günter Plunien[5], Wolfgang Quint[3], Günter Werth[2], Vladimir M. Shabaev[4], and Klaus Blaum[1] — [1]MPI für Kernphysik, 69117 Heidelberg, Germany — [2]Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany — [3]GSI, 64291 Darmstadt, Germany — [4]Deparment of Physics, St. Petersburg State University, St. Petersburg 198504, Russia — [5]Institut für Theoretische Physik, TU Dresden, 01062 Dresden, Germany

High-precision measurements of the g factor of the valence electron bound in a many-electron system provide excellent possibilities to test the relativistic interelectronic interaction. This is particularly true for 3-electron systems, since they can be calculated with high precision. Moreover, for heavy elements a comparison of the g factors of the lithium- and the hydrogenlike charge state of the same isotope allows for a better test of bound-state QED calculations [1]. To this end we have determined the g factor of $^{28}Si^{11+}$ with the double-trap technique [2]. It is derived from a measurement of the Larmor precession frequency and the free cyclotron frequency of a single ion confined in a cylindrical Penning trap. Our result has an uncertainty of $\delta g/g = 1.1 \cdot 10^{-9}$ and is in excellent agreement with the theoretical value [3]. The measurement technique and the results will be presented.

[1] Shabaev *et al.*, Phys. Rev. A **65**, 062104 (2002)
[2] Häffner *et al.*, Eur. Phys. J. D **22**, 163 (2003)
[3] Wagner *et al.*, Phys. Rev. Lett., submitted (2012)

A 15.4 Tue 12:00 B 305

The proton g-factor — •Sascha A. Bräuninger[1,3], Klaus Blaum[1,3], Holger Kracke[2,4], Clemens Leiteritz[2], Andreas Mooser[2,4], Wolfgang Quint[3,5], Cricia Rodegheri[1,2], Stefan Ulmer[1,6], and Jochen Walz[2,4] — [1]Max-Planck-Institut für Kernphysik, D-69117 Heidelberg — [2]Johannes Gutenberg-Universität, D-55099 Mainz — [3]Ruprecht Karls-Universität, D-69047 Heidelberg — [4]Helmholtz Institut, D-55099 Mainz — [5]Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt — [6]Riken Advanced Science Institut, Wako, Saitama 351-0198, Japan

The aim of our experiment is the first direct high-precision measurement of the g-factor of a single proton with a relative precision of 10^{-9} or better. The g-factor is determined by the ratio $g = 2\frac{\nu_L}{\nu_c}$ of the free cyclotron frequency ν_c and the Larmor frequency ν_L. ν_c is determined by the three eigenfrequencies of the trapped proton. ν_L is extractable by a measured probability distribution given by the number of induced spin transitions driven by an external field as a function of the excitation frequency. The continuous Stern-Gerlach effect is utilized to detect the induced spin transitions in a second Penning trap with an inhomogenous magnetic field. A change of the spin state due to an excitation of the magnetic dipole transition results in a change of the axial eigenfrequency. The status of the experiment and current developments with a measurement at the 10^{-6} level are presented.

A 15.5 Tue 12:15 B 305

Electron correlation effects in resonant photorecombination and excitation processes with highly charged ions — •Zoltán Harman[1,2] and Christoph H. Keitel[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg — [2]ExtremeMe Matter Institute EMMI, Darmstadt

Relativistic electron correlation effects greatly determine the recombination and excitation dynamics of highly charged ions, and thus the time evolution of astrophysical and magnetically confined plasmas. In case of resonant recombination, we have found that three-body correlation effects may give rise to significant additional reaction channels beyond what is known from the usual two-body theory describing dielectronic recombination [1]. Bound-electron correlation effects also determine the intensity of x-ray emission of highly charged ions excited by photons or electron collisions in stellar plasmas. These intensities play an important role in astrophysical modeling and in the analysis of spectra recorded by space observatories. We compare our theoretical results to experimental measurements with electron beam ion traps [1,2]. – [1] C. Beilmann *et al.*, Phys. Rev. Lett. **107**, 143201 (2011). [2] S. Bernitt *et al.*, Nature, **492**, 225 (2012).