# A 4: Collisions, scattering and correlation phenomena I

Time: Monday 11:00–12:15 Location: f107

A 4.1 Mon 11:00 f107

**Electron-impact ionization of beryllium-like carbon ions** — •Benjamin Ebinger[1,2], Alexander Borovik Jr.[1,2], Stefan Schippers[1,2], and Alfred Müller[2] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen — [2]Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Gießen

Reliable atomic input data are of crucial importance for the modelling of ionized-matter environments. Cross sections for electron-impact ionization of atoms and ions are particularly important. Besides the fairly well understood direct-ionization process, indirect ionization mechanisms such as excitation-autoionization (EA) and resonant-excitation double autoionization (REDA) may significantly contribute to net single-ionization [1]. Benchmark experiments uncovering fine structures that arise from indirect ionization in few-electron systems provide guidance for theoretical efforts to adequately describe total single ionization by electron collisions. Here, we present measurements of electron-impact single-ionization cross sections of the $C^{2+}$ ion, i. e., of a fairly simple four-electron system. Complications arise, however, from the presence of both $1s^2 2s^2\,{}^1S_0$ ground-level and $1s^2 2s 2p\,{}^3P_{0,1,2}$ metastable-level ions in the experiment. Employing the well-established fine-step energy-scan technique [2], contributions of indirect-ionization processes invoked by excitation of the K-shell were uncovered with a statistical uncertainty of less than 0.03% thus helping to disentangle the various cross-section contributions.

[1] Liu et al., Phys. Rev. A 92 (2015) 012701
[2] A. Müller et al., Phys. Rev. Lett. 61 (1988) 70

A 4.2 Mon 11:15 f107

**Correlated reduced density operators of quantum lattice models** — •Konstantin Krutitsky, Andreas Osterloh, and Ralf Schützhold — Fakultät für Physik der Universität Duisburg-Essen, Campus Duisburg, 47048 Duisburg

We present a systematic study of nonlocal correlations in quantum lattice models. With this purpose in mind we introduce correlated reduced density operators for arbitrary number of lattice sites $q$ located at arbitrary distances from each other. Quantitative estimates of the nonlocal correlations are obtained calculating the Schatten $p$-norms of the correlated reduced density operators. For the Bose-Hubbard model in the case of unit filling, the Schatten norms with $p = 1$ (trace norm) decrease with the number of sites $q$ in the Mott-insulator phase and increase in the superfluid phase, while the norms with $p = 2$ (Frobenius norm) decrease in both phases. For the transverse Ising model, the $p = 1$ and $p = 2$ norms decrease with the number of sites $q$ in the disordered phase below the critical point. However, near and above the critical point the norms display a nonmonotonic behavior with respect to $q$. These results can be useful for the development of controlled approximations for the solution of quantum lattice models.

A 4.3 Mon 11:30 f107

**New ficticious force in electron-atom/ion scattering** — •Hubert Klar — DHBW Lörrach

We treat two-elctron atoms (like He) in the nonrelativistic frame. We derive for the e-e interaction a momentum-dependent ficticious force in addition to the electrostatic interactions. In contrast to other ficticious forces in mechanics our force constitutes an entirely new quantum effect. The diffraction of an electron wave from the three-body Coulomb potential surface induces an e-e force. This effect has only little influence onto the lower part of the spectrum, and was therefore overlooked sofar. High double excitation, however, changes dramatically.

A 4.4 Mon 11:45 f107

**Setup of a high-resolution Seya-Namioka-type fluorescence spectrometer for the spectral range between 35 nm and 180 nm for experiments at ion storage rings** — •Philipp Reiss, Philipp Schmidt, Christian Ozga, André Knie, and Arno Ehresmann — University of Kassel, Institute of Physics and CINSaT, Heinrich-Plett-Str. 40, 34132 Kassel

A Seya-Namioka type spectrometer for the detection of highly resolved dispersed fluorescence in the wavelength range between 35 nm and 180 nm for experiments at gas- and electron targets and electron coolers at the FAIR facility will be set up. Depending on the experimental requirements, optical reflection gratings with a short focus (f = 1 m) for a higher solid angle coverage of the emitted fluorescence and a resolution of $\Delta\lambda = 0.3$ nm or a grating with a long focus (f = 3 m) for high resolution ($\Delta\lambda = 0.1$ nm) will be used. The pursued high resolution will enable the determination of the degree of ionization as well as the radiative states of excited ions via their emitted fluorescence wavelengths and thus help answering a variety of scientific questions. A characterization of the gas target or the longitudinal ion bunch profiles is also possible.

A 4.5 Mon 12:00 f107

**Pikosekunden Masteroszillator-Faserverstärker-System zur Ionenstrahlkühlung** — •Daniel Kiefer, Tobias Beck und Thomas Walther — Technische Universität Darmstadt, Institut für Angewandte Physik, Laser und Quantenoptik, Schlossgartenstr. 7, 64289 Darmstadt

Laserkühlung von relativistischen Ionenstrahlen wurde bereits mehrfach erfolgreich erprobt. Hierbei wurde entweder die Energiedifferenz des Kühlübergangs manipuliert [1] oder, als neuere Methode, der Laser periodisch in seiner Frequenz verstimmt [2]. Bei beiden Techniken gehen Ionen durch Coulombstöße untereinander (intra-beam-scattering) für den Kühlvorgang verloren. Um diese Verluste zu verringern, wurde Kühlen mit Hilfe von spektral verbreitertem Laserlicht vorgeschlagen (white-light-cooling) [3]. Hierzu präsentieren wir ein gepulstes Masteroszillator-Faserverstärker-System, das sich im Aufbau befindet. Die erforderliche spektrale Breite wird über Fourier-transform limitierte Pulse und entsprechend gewählte Pulslängen eingestellt. Als Masteroszillator dient ein ECDL bei 1028 nm dessen Licht zunächst in einer Ytterbium-dotierten Faser verstärkt wird. Mit Hilfe akustooptischer und elektrooptischer Modulation in Mach-Zehnder Konfiguration werden Pulse mit einer Länge zwischen 70 ps und 700 ps bei einer Wiederholrate von 0,5 bis zu 1,5 MHz erzeugt. Der Pulserzeugung schließen sich zwei weitere Ytterbium-basierte Faserverstärker an. Im Vortrag wird der Status des Aufbaus diskutiert. [1] S. Schröder et al, Phys. Rev. Lett. 64 (1990), 2901-2904. [2] T.Beck, Dissertation, TU-Darmstadt, (2014). [3] J. Hoffnagle, Opt. Lett. 13(2) (1988):102.