SYAP 1: Atomic and Plasma Physics at FAIR

Time: Tuesday 11:00–13:00 Location: P 1

Invited Talk SYAP 1.1 Tue 11:00 P 1

Electrons and ions meet ultracold atoms — •Herwig Ott — Fachbereich Physik, Universität Kaiserslautern

Bringing together ultracold atoms and charged particles opens up new research directions in atomic physics. On the one hand, electrons and ions can be used to probe and manipulate ultracold atomic gases. On the other hand, a sample of ultracold atoms is an ideal starting point to generate ultracold electron and ion beams. Also spectroscopic techniques can be readily transferred between the two platforms. Altogether, the combination of charged particles and ultracold atoms allows to explore new physical phenomena and provides new analysis tools for various experimental observables.

In this talk I will give three examples, how both research fields can benefit from each other. First, I will show that a focused electron beam can be used to provide a controlled source of dissipation to a many-body quantum system. I will then discuss how correlated electronic excitations in an ultracold gas can be mapped onto a correlated ion string. And finally, I will present first results towards the generation of a high-repetition deterministic single ion source based on ultracold atoms.

Invited Talk SYAP 1.2 Tue 11:30 P 1

Interrogating strongly bound electrons about fundamental physics — •José R. Creso López-Urrutia — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Electronic wavefunctions in bound systems are in principle sensitive to all fundamental interactions, and precision spectroscopy thus provides information not only on quantum electrodynamics, nuclear size effects and parity violation studies, but also on other sectors of the standard model of physics. For electrons strongly bound in deep shells, the sensitivities to the different interactions are naturally enhanced by orders of magnitude. In highly charged ions (HCI), complicated electron-electron interactions are largely reduced, simplifying the theoretical analysis of experiments exploiting those sensitivities. Novel methods have been proposed, potentially capable of interrogating the time stability of fundamental constants using frequency metrology by means of optical clocks of ultimate precision. We pursue a double approach: finding electronic transitions with the appropriate characteristics [1], and cooling HCI to the required low temperatures [2]. Furthermore, we are preparing experiments aiming at extending frequency metrology to the extreme ultraviolet and soft x-ray region and accessing even more interesting electronic transitions in HCI. [1] A. Windberger et al., Phys. Rev. Lett. 114, 150801 (2015) [2] L. Schmöger et al., Science 347, 1233 (2015)

Invited Talk SYAP 1.3 Tue 12:00 P 1

Strong-field effects in heavy-ion collisions — •Andrey Surzhykov[1,2], Vladimir Yerokhin[3], Thomas Stöhlker[4], and Stephan Fritzsche[4] — [1]Physikalisch-Technische Bundesanstalt, Germany — [2]Technische Universität Braunschweig, Germany — [3]Peter the Great St. Petersburg Polytechnic University, Russia — [4]Helmholtz-Institut Jena, Germany

A series of experiments are planned to be performed at the future FAIR facility with the aim of studying strong-field phenomena in heavy-ion collisions. Of special interest here is the electron-positron pair production either for low projectile velocities, for which super-heavy quasi-molecules can be formed, or in strong relativistic regime. In this presentation, we will review recent theoretical advances in the description of both low– and high–energy ion–atom and ion–ion collisions. In particular, we discuss the non-perturbative treatment of the electron dynamics in quasi-molecular systems, such as $U^{92+} + U^{91+}$. For the high-energy regime, new predictions will be presented for the recombination of a target electron into a bound state of an initially bare nucleus with the simultaneous creation of a e^+–e^- pair. For this so-called negative continuum dielectronic recombination (NCDR) process we study the effects of the atomic target on the single and double-differential cross sections [1]. Finally, the lepton pair production in highly-relativistic bare ion collisions will be revisited with the special focus on the angular distribution of emitted positrons.

[1] V. A. Yerokhin *et al.*, Phys. Rev. A **92**, 042708 (2015).

Invited Talk SYAP 1.4 Tue 12:30 P 1

Laser-based high photon flux XUV sources and applications in atomic physics — •Jan Rothhardt[1,2], Robert Klas[1,2], Stefan Demmler[1,2], Maxim Tschernajew[1,2], Jens Limpert[1,2,3], and Andreas Tünnermann[1,2,3] — [1]Helmholtz Institut Jena — [2]Institut für Angewandte Physik, Friedrich-Schiller-Universität Jena — [3]Fraunhofer IOF Jena

XUV sources based on high harmonic generation with femtoseocnd fiber lasers can nowadays provide a very high photon flux on a tabletop. We will present the latest developments in this field including a mW-average power XUV source which will be applied for photoionization experiments and fluorescence spectroscopy of highly-charged ions at heavy-ion acellerators inculding the future FAIR facility.