SYHC 1: Highly Charged Ions for Atomic, Nuclear and Astrophysics

Time: Monday 11:00–13:00 Location: E415

Invited Talk SYHC 1.1 Mon 11:00 E415

First experiments at CRYRING@ESR — •Esther Babette Menz[1,2,3], Michael Lestinsky[1], Håkan Danared[4], Claude Krantz[1], Zoran Andelkovic[1], Carsten Brandau[1,5], Angela Bräuning-Demian[1], Svetlana Fedotova[1], Wolfgang Geithner[1], Frank Herfurth[1], Anton Kalinin[1], Ingrid Kraus[1], Uwe Spillmann[1], Gleb Vorobyev[1], and Thomas Stöhlker[1,2,3] for the SPARC-Collaboration — [1]GSI, Darmstadt — [2]Helmholtz-Institut Jena — [3]IOQ, Friedrich-Schiller-Universität Jena — [4]European Spallation Source, Lund — [5]I. Phys. Institut, Justus-Liebig-Universität Giessen

After its move from Stockholm and successull commissioning at its new site at GSI, CRYRING@ESR is now in operation and able to accept previously inaccessible ion species available from the accelerator complex as well as a smaller selection from a local injector. As a user facility is serves experiments on nuclear and atomic physics proposed through the SPARC collaboration as well as material science experiments at the newly installed extraction beamline. In the last few years a number of new experimental setups have been installed, tested and used for first experiments. These include a dielectronic recombination setup as well as a microcalorimeter-based X-ray spectroscopy setup that make use of the ultra-cold electron cooler to perform merged-beam experiments and a gas jet target for atomic collisions in the experimental section. We will give an overview of the setup and the progress in recent years, present data from the first experiments and take a look at the plans for upcoming beamtime periods.

Invited Talk SYHC 1.2 Mon 11:30 E415

Testing quantum electrodynamics in the simplest and heaviest multi-electronic atoms — •Martino Trassinelli for the SPARC-Collaboration — CNRS, Institut des NanoSciences de Paris, Paris, France

Transition energy measurements in heavy, few-electron atoms allow to test bound-state QED in extremely high Coulomb fields, which enhance the impact of the quantum vacuum fluctuations on the atomic energies. Up to now, experiments have been unable to achieve sensitivity to higher-order QED effects in extremely strong fields. Here we present a novel multi-reference method based on Doppler-tuned x-ray emission from stored Uranium ions with different charge states. By performing high-accuracy x-ray spectroscopy of two, three, and four electron uranium ions in the same measurement campaign, we could obtain the absolute energy of the $1s_{1/2}2p_{3/2} \rightarrow 1s_{1/2}2s_{1/2}$ transition with an accuracy of 0.17 eV, a factor of six improvement over previous measurement. This allows to be sensitive to two-loop quantum electrodynamics effects in heavy highly charged ions. Furthermore, by comparing the transition energy in helium-like uranium transition to similar transitions in lithium-like and beryllium-like uranium, the contribution of electron-electron interaction, i.e. two-electron QED, in heavy bound systems could be disentangled from the one-electron QED contributions and from the uncertainty related to the nuclear radius. This result excludes a number of the most-accurate state-of-the-art theoretical predictions and represents a new paradigm for precision tests of bound-state QED.

Invited Talk SYHC 1.3 Mon 12:00 E415

Indirect measurements of neutron-induced reaction cross-sections at heavy-ion storage rings — •Beatriz Jurado — LP2i, Bordeaux, France

Obtaining reliable cross sections for neutron-induced reactions on unstable nuclei nuclei is crucial to our understanding of the stellar nucleosynthesis of heavy elements and for applications in nuclear technology. However, the measurement of these cross sections is very complicated, or even impossible, due to the radioactivity of the targets involved. The NECTAR (Nuclear rEaCTions At storage Rings) project aims to circumvent this problem by using the surrogate-reaction method in inverse kinematics at heavy-ion storage rings, which offer unique and largely unexplored possibilities for the study of nuclear reactions. In this talk, I will present the setup and the new methodology, which we are developing within NECTAR to perform high-precision surrogate-reaction experiments at the heavy-ion storage rings of the GSI/FAIR facility. In particular, I will present the first results of the proof of principle experiment, which we successfully conducted in June 2022 at the ESR storage ring of GSI/FAIR.

Acknowledgement: This work is supported by the European Research Council (ERC) under the European Union Horizon 2020 research and innovation program (ERC-Advanced grant NECTAR, grant agreement No 884715).

Invited Talk SYHC 1.4 Mon 12:30 E415

Laboratory X-ray Astropohysics with Trapped Highly Charged Ions at Synchrotron Light Sources — •Sonja Bernitt — Helmholtz-Institut Jena, Germany — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The newest generation of high-resolution UV and X-ray spectroscopic instruments onboard current and future satellite observatories has the potential to uncover previously inaccessible details of processes in astrophysical plasmas, such as the ones found in galaxy clusters and in the proximity of active galactic nuclei. This is essential for advancing our understanding of extreme environments and the evolution of the universe.

However, what can be reconstructed from spectra is currently limited by the availability and quality of atomic data, which are the basis for plasma models. That is especially the case for highly charged ions (HCI), ubiquitous in hot astrophysical environments. Laboratory measurements are necessary to provide atomic data, like transition energies, as well as rates of excitation and ionization processes.

Here, work with electron beam ion traps (EBITs) is presented, in which radiation from ultrabrilliant UV and X-ray synchrotron light sources is used to resonantly excite electronic transitions in trapped HCI. Subsequent fluorescence and changes in ion charge state are detected, allowing to gather spectroscopic data, reaching unprecedented resolving powers and signal-to-noise ratios. This has led to a variety of new insights into questions related to astrophysics.