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High Precision Measurements with Stored Highly Charged Radioactive Ions

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Employing storage rings for precision physics experiments with highly-charged ions (HCI) at the intersection of atomic, nuclear, plasma and astrophysics is a rapidly developing field of research. Storage of freshly produced secondary particles in a storage ring is a straightforward way to achieve the most efficient use of the rare species. It allows for determining the mass of the species through the revolution frequency measurement as well as its lifetime by waiting until it decays and often also the decay branching. Furthermore, in reaction studies it allows for using the same secondary ion multiple times thus increasing the reaction luminosity. The number of physics cases is enormous. In the focus of this presentation will be the most recent results obtained at the cooler storage rings ESR of GSI in Darmstadt and CSRe of IMP in Lanzhou.

Both the ESR and CSRe rings are coupled to in-flight fragment separators and are employed for precision mass spectrometry of short-lived rare nuclei. At the CSRe, the enabled measurement of the velocity of every stored particle—in addition to its revolution frequency—has boosted the sensitivity and precision of mass measurements. One of the highlight recent results are the mass determinations around the 64Ge waiting point in the rp-process nucleosynthesis and the mass of 22Si.

The ESR is presently the only instrument dedicatedly utilized for precision studies of decays of HCIs. Radioactive decays of HCIs can be very different as those known in neutral atoms. One of the exotic decay modes is bound-state beta decay, where the beta electron is created in the free electron orbital. The recent measurement of the half-life of 205Tl of about 1 year, which is stable as atom, provided new insights into the origin of the Solar system and strict constraints on the geochemical neutrino project LOREX. Regarding short-lived systems, the application of highly sensitive non-destructive cavity-based Schottky detectors enabled mass-resolved decay studies in the millisecond range. In the absence of bound electrons, the electron conversion is disabled leading to longer lifetimes. Thus, isolated two-photon decays of first excited 0+ states in 72Ge as well as 98Zr and 98Mo could be addressed.

The experiments performed at the ESR and CSRe will be put in the context of the present research programs in a worldwide context, where, thanks to fascinating results obtained at the presently operating storage rings, a number of projects is planned. Several experiments are planned in Spring 2025 at the ESR, CSRe and the dedicated low-energy CRYRING. Dependent on the progress of these experiment, some fresh results might be available to be reported at the conference.

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