Towards Precision Tests of Bound-state QED in U^{90+} Using Novel Metallic Magnetic Calorimeter Detectors

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Helium-like ions are the simplest atomic multi-body systems. Their study along the iso-electronic sequence provides a unique testing ground for the interplay of the effects of electron–electron correlation, relativity and quantum electrodynamics (QED). Especially heavy highly charged ions are ideal for testing higher-order QED terms. Their contributions are on the 1 eV level for transition energies of 100 keV. However, for ground state transitions in ions with nuclear charge $Z > 54$, where photons reach such energies, there is currently no data available with sufficient resolution and accuracy to challenge state-of-the-art theory [1]. In this context, the recent development of metallic magnetic calorimeter (MMC) detectors is of particular importance. Their high spectral resolution of a few tens of eV FWHM at 100 keV incident photon energy, in combination with a broad spectral acceptance down to a few keV, will enable new types of precision X-ray experiments [2, 3].

First X-ray spectroscopy studies at the electron cooler of the low-energy storage ring CRYRING@ESR at GSI, Darmstadt have recently been performed for highly-charged ions [4, 5]. We report on the second campaign where MMC detectors have been used to study X-ray emission associated with the formation of excited helium-like uranium (U^{90+}) as a result of radiative recombination between stored U^{91+} ions and cooler electrons. The achieved spectral resolution of better than 90 eV at X-ray energies close to 100 keV enabled us to resolve the substructure of the $K\alpha_1$ and $K\alpha_2$ lines for the first time. This fivefold resolution improvement, compared to previous studies paves the way for future precision tests of strong-field QED and many-body effects.

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