Precision x-ray spectroscopy of the 1s Lamb shift in high-Z hydrogen-like systems

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The study of the 1s Lamb shift in hydrogen-like systems represents one of the most stringent tests of quantum electrodynamics (QED) for the most fundamental atomic systems. Due to the strong dependence of the Lamb shift on the nuclear charge Z, it is of high interest to test the predictions of QED in the regime of very strong electric fields, such as in hydrogen-like gold (Au^{78+}) or uranium (U^{91+}), where approximations relying on $\alpha Z \ll 1$ are not applicable. The present contribution will focus on most recent efforts with respect to high-precision Lamb shift studies in high-Z systems at GSI, Darmstadt.

After several experiments on the 1s Lamb shift in U^{91+}, conducted with conventional semiconductor detectors [3], the twin crystal spectrometer FOCAL has been developed [4] which is the result of a well-balanced trade-off between a high resolving power and detection efficiency. Namely, an acceptable efficiency is needed to operate the crystal spectrometer at an ion storage ring with a luminosity which is low compared to other high intensity x-ray sources like synchrotrons or nuclear reactors. The outcome of the first beam time using the complete two-arm FOCAL spectrometer will be presented, see Fig. 1. In addition, the development of microcalorimeters for the x-ray regime, that combine the high resolution typical for crystal spectrometers with the good efficiency of conventional solid state detectors, is expected to open a promising route for precision spectroscopy in high-Z systems. Here, we will discuss recent test measurements with the maXs prototype detector [5] as depicted in Fig. 2.

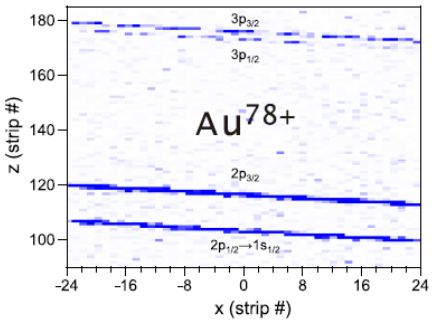

Figure 1: X-ray spectrum of hydrogen-like gold as recorded by a position sensitive detector after being dispersed by the FOCAL crystal. The lines correspond to the Lyman-α and -β transitions in Au^{78+}.

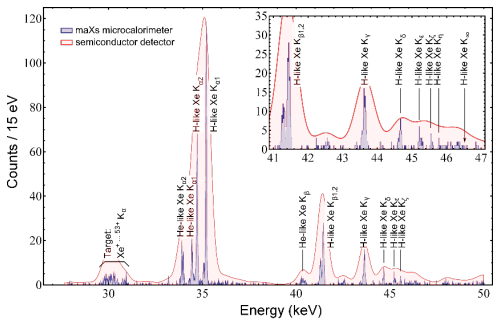

Figure 2: X-ray spectrum from the collision of a Xe^{54+} ion beam and a Xe gas target. The Doppler-shifted Lyman series of Xe^{53+} and Xe^{52+} are clearly visible. Centered around 30 keV one can see the K-lines of differently charged Xe ions from the target gas.

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[5] D. Hengstler et al., Phys. Scr. **2015**, 014054 (2015).