Development of a VUV-VIS-Spectrometer for Target Characterisation

Ph. Reiß[*1], *A. Knie*[1], *and A. Ehresmann*[†1]
[1]Institute of Physics and CINSaT, University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

Fluorescence Spectroscopy in the visible, ultraviolet and VUV spectral range is a powerful experimental technique for the investigation of quantum-mechanical interference and electron correlative processes in atoms, molecules, and their ions. Energy differences between the two involved levels of the radiative transitions can be determined accurately, the recorded fluorescence intensity is a measure for the population probability of the fluorescence transitions initial state and a polarization analysis enables an analysis of the population of the energetically degenerate magnetic sublevels.

Advantages of Fluorescence Spectrometry

In synchrotron radiation experiments fluorescence spectrometry has proven to be an outstanding tool due to its state selectivity. The possibility to determine energies of doubly excited states in rare gas atoms demonstrates this feature nicely. In these experiments energies of individual autoionizing Rydberg states of two-electron excitations were determined. The state specificity of the autoioinzation processes into particular final states (which have been the initial states of the fluorescence transitions) enabled an individual determination of Rydberg states energies, being completely impossible in absorption experiments due to the high density of all doubly excited Rydberg states contributing to the absorption signal [1]. An example of such an experiment is shown in Figure 1 for Rydberg series of Kr doubly excited states.

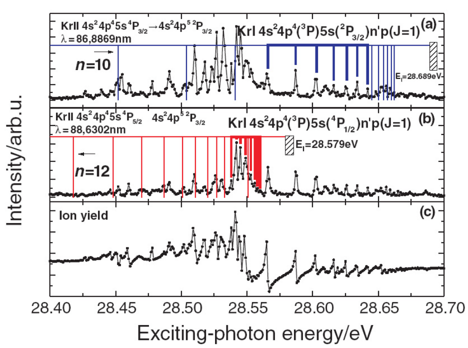

Figure 1: Dispersed fluorescence intensities from excited KrII $4s^24p^45s\ ^4\mathrm{P}_{3/2}$ (a) and $4s^24p^45s\ ^4\mathrm{P}_{3/2}$ (b) satellite states after photon excitation with energies around 28.55eV as well as the total photoion yield (c). Rydberg series of autoionizing two-electron resonances are clearly visible and can be distinguished.

Usage at Heavy-Ion Storage Rings

Fluorescence spectrometry used for the investigations of atomic or molecular ions formed after impact of heavy ions will be invaluable to conclude on the possible formation processes and on the involved electronic states. Also, a diagnosis of the ion beam itself after an impact in gaseous targets and foils is an intended aim of the project. Processes to be investigated will be radiative electron capture and dielectronic recombination.

Experimental setup and status of the project

The setup consists of a McPherson Model 225 1m-normal-incidence spectrometer that can be equipped with interchangeable diffraction gratings for the dispersion of the fluorescence radiation, each optimized for a different spectral range (VUV-VIS spectral range).

The detection of the photons is performed by 2-dimensional position- and time-resolving single-photon detectors that allow the simultaneous measurement of several fluorescence lines within a certain fluorescence wavelength range. Time resolution offers the option for lifetime or coincidence measurements.

Two detectors with wavelength ranges of 190nm to 700nm for the visible and 115nm to 300nm for the UV and VUV spectral range have been ordered from Quantar Technology and will be tested upon delivery. A third detector for the EUV spectral range from 30nm to 150nm will be assembled at the University of Kassel and also tested after completion.

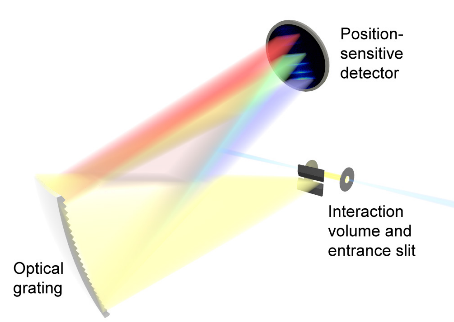

Figure 2: Sketch of the spectrometer setup.

References

[1] A. Ehresmann, et. al., J. Phys. B: At. Mol. Opt. Phys: 37, L251

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† ehresmann@physik.uni-kassel.de