Resonant excitation of electronic transitions in highly charged ions with x-ray radiation from ultrabrilliant light sources

Sven Bernitt*† [1], René Steinbrügge‡†, Stepan Dobrodey†, Steffen Kühn†, Peter Micke§†, Jan K. Rudolph¶†, Sascha W. Epp◊, Thomas Stöhlker*, José R. Crespo López-Urrutia†

* Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität, 07743 Jena, Germany
† Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany
‡ TRIUMF, Vancouver, BC V6T 2A3, Canada
§ QUEST Institute, Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany
¶ Institut für Atom- und Molekülphysik, Justus-Liebig-Universität, 35392 Giessen, Germany
◊ Max-Planck-Institut für Struktur und Dynamik der Materie, 22761 Hamburg, Germany

Synopsis A transportable electron beam ion trap (EBIT) has been used to probe the electronic structures of highly charged ions by resonantly exciting transitions with x-ray radiation from free-electron lasers and synchrotrons. The measured atomic data is used in the interpretation of astrophysical spectra, to test atomic theory and for metrological applications.

By resonantly exciting electronic transitions with monochromatic light and recording the induced fluorescence as a function of the light wavelength, it is possible to directly probe the electronic structures of atoms, molecules and ions. This technique, commonly known as laser spectroscopy, is widely used in physics and chemistry, yielding highly accurate spectroscopic data. In recent years, the advent of the newest generation of ultrabrilliant light sources – synchrotrons and free-electron lasers – has enabled its application in the previously unaccessible x-ray regime.

The transportable electron beam ion trap FLASH-EBIT has been used in a number of experiments to provide targets of trapped highly charged ions for VUV and x-ray radiation from FLASH [1,2], LCLS [3], BESSY II [4] and PETRA III [5,6,7]. Our measurements have provided accurate transition energies [1,2,5,7], natural line widths [5,6], and relative oscillator strengths [3]. By detecting changes of ion charge states we were also able to detect resonant photoionization [4] and deduce branching ratios as well as absolute radiative and Auger decay rates [6].

The atomic data obtained is valuable for the interpretation of astrophysical x-ray spectra [3], such as the ones expected from future satellite missions like the JAXA/NASA X-ray Astrophysics Recovery Mission (XARM) or ESA's ATHENA, where a lack of high accuracy spectroscopic data still limits the possible scientific gain.

Furthermore, the study of high-Z few-electron systems provides benchmarks of atomic theory on the level of QED contributions [5,7].

We have also developed a new compact electron beam ion trap based on permanent magnets, called PolarX-EBIT, to investigate the possible use of electronic transitions in highly charged ions as future x-ray wavelength standards, and explore new applications for spectroscopy, metrology and polarimetry.

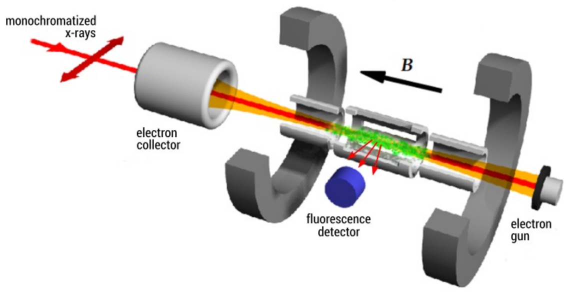

Figure 1. X-ray laser spectroscopy in an EBIT. The x-ray photon beam is axially overlapped with the ion cloud and resonantly excited fluorescence is detected.

References

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1 E-mail: sven.bernitt@mpi-hd.mpg.de