Spectroscopy of few-electron, highly charged ions with the Freiburg electron beam ion trap FreEBIT

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First results from the new Freiburg electron beam ion trap [1] will be reported. Highly charged ions of xenon, barium, tungsten and krypton have been observed with charge states up to 60+ by means of X-ray spectroscopy. Current status, upgrades and future experiments will be outlined.

The electron beam ion trap (EBIT) [2] has provided a new tool for the study of highly charged ions (HCIs). EBIT Facilities are now operational in the US, UK, Germany, and Japan. This type of trap uses a magnetically compressed electron beam to ionize and trap ions at the same time. The highest charge states (up to U^{92+}) can be produced by such a device under steady state conditions. The Freiburg facility (FreEBIT) is based on the experience gained at the original EBITs developed at the Lawrence Livermore National Laboratory [2]. However, FreEBIT is specifically designed as a combination of ion trap and ion source which can deliver an ion beam to cold target recoil ion momentum spectroscopy (COLTRIMS) [3] experiments and simultaneously be used for spectroscopy of the trapped HCIs in the x-ray, soft x-ray, VUV, UV, and visible region. The needs of such experiments have required a complete redesign of the trap.

The initial runs used among others elements xenon and barium. The identification of the ion species produced was carried out by X-ray spectroscopy. A Ge-Li photon detector allowed to resolve the lines generated whenever highly charged ions in the trap recombine radiatively (RR) - *i.e.* inverse photoelectric effect - with the beam electrons. An example of these early results (see Fig. 1) shows xenon ions with open L-shell, i.e., charge states ranging from q=51+ to 45+.

Presently, the trap is already operational. FreEBIT can now produce and trap ions comparable with most other existing EBITs, and allow their study under steady-state conditions. An overview over the main current projects will be given. These are: (1) Upgrade to high energy (300 keV) operation, (2) a laser ablation ion source to inject low charge ions from solid targets into FreEBIT, (3) spectral measurements of forbidden lines and hyperfine structure of HCIs in the optical region, (4) the setup of the ion extraction, mass selection system, acceleration beam line, and COLTRIMS apparatus.

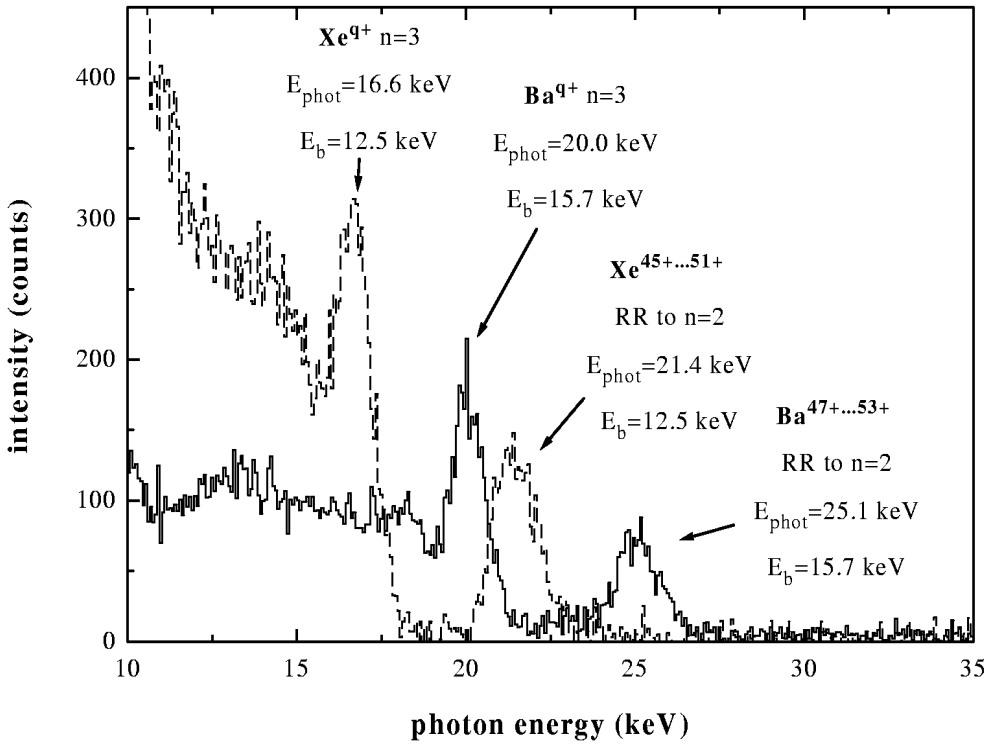

Figure 1: X-ray lines due to radiative recombination (RR) into different open shells of trapped highly charged ions in FreEBIT. Dashed: Xe run at an electron beam energy of Eb=12.5 keV; solid: Ba run at Eb=15.7 keV with Ne cooling gas.

[1] J. R. Crespo López-Urrutia, A. Dorn, R. Moshammer and J. Ullrich, *Phys. Scr.* **T80** 502 (1999).

[2] R. E. Marrs, P. Beiersdorfer and D. Schneider, "The Electron Beam Ion Trap", *Physics Today* **V47** N10 27(October 1994).

[3] J. Ullrich *et al.*, *Comments At. Mol. Phys.* **30(5)** 285 (1994).