Electron-impact Excitation of Hydrogenlike Uranium Ions[*]

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Electron-impact excitation (EIE) of bound electrons is one of the most fundamental processes and leads to the specific formation of spectral lines. In particular, it is responsible for the vast majority of x-ray radiation produced in various kinds of plasmas, in high energy density physics experiments and at laboratory fusion devices. Relativistic and retardation effects are known to affect the EIE process through the generalized Breit interaction (GBI) [1, 2].

Up to now, electron beam ion traps (EBITs) have been the preferred tool for studying the EIE [3]. Due to the small electron-impact ionization and excitation cross sections for heavy highly-charged ions, the focus of most of these EBIT studies has been confined to relatively low-Z systems.

In this contribution, we present an experimental and theoretical study of the electron-impact excitation effects in hydrogen-like uranium in relativistic collisions with different gaseous targets. The experiment was conducted at the experimental storage ring ESR. Recent developments, such as the anti-coincidence mode [4] and new micro-droplet target development [5], have rendered such studies feasible. By performing measurements with different targets as well as with different collision energies, we were able to gain access to both; proton (nucleus) impact excitation (PIE) and electron impact excitation (EIE) processes in the relativistic collisions. The large fine-structure splitting in H-like uranium allowed us to unambiguously resolve excitation to different L-shell levels. By looking at the intensity ratios of ($Ly\alpha_1/Ly\alpha_2$) of the subsequent decay photons, we were able to clearly identify and study the effect of the electron-impact excitation in H-like uranium (see Fig. 1). Combined calculations which treat both processes, PIE and EIE, provide a good agreement with the experimental data. Moreover, our experimental results clearly demonstrate the importance of including the effect of the GBI in the EIE calculations.
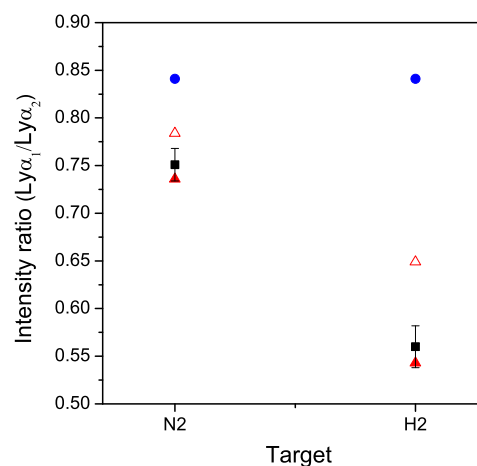

Figure 1: Experimental results (solid black squares) in comparison with theoretical predictions for $Ly\alpha_1/Ly\alpha_2$ ratios for the K-shell excitation of U^{91+} in collisions with N_2 and H_2 targets at 212.9 MeV/u. Solid blue circles show PIE results. Solid red triangles depict combined (PIE+EIE) calculations. In addition, the combined calculations are presented without inclusion of the GBI, by empty red triangles.

References

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