Projectile Excitation Studies for High-Z Ions at the ESR Storage Ring

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The formation of excitated states via Coulomb excitation can be studied uniquely for H-like high-Z ions by the observation of the radiative decay of excited levels to the groundstate. This has been demonstrated in a first experimental study for Bi-ions [1]. In that work a fully relativistic formalism was applied for data interpretation in which the transition amplitude is calculated by taking into account the complete Liénard-Wiechert interaction. For a detailed discussion we refer to Ref.[2][3]. As reported in Ref. [1][2], the inclusion of the complete interaction leads to a substantial reduction of the cross sections compared to the commonly used quasi-relativistic approach, where the electric and magnetic terms are added incoherently [4]. The subshell resolved experimental data measured for H-like Bi supported the complete calculations. However, in that experimental study solid targets were used and the results suffered from low counting statistics. We extended these studies in an experiment at the ESR jet target where the K-shell excitation cross sections where investigated for H-like gold ions in collisions with Ar atoms. The interaction zone between the ion beam and the Ar gas-jet was viewed by various Ge x-ray detectors at different observation angles. The down-charged projectile ions were observed after the next dipole magnet with a scintillator detector. By measuring the projectile x-rays in anti-coincidence with the ions undergoing charge-exchange in the interaction zone, intense x-ray spectra due to excitation where observed. The excellent beam conditions and high detection efficiency allowed us to obtain very clean x-ray spectra for H-like Au, where even transitions from high n-levels could be identified.

In Fig. 1 a comparison between the experimental data and the complete theoretical calculations with the magnetic part of the Liénard-Wiechert potential is shown. The Lyman-α_2 line was normalized to the theoretical line strength. The figure points out that there is a very good agreement between the experiment and the complete theory. To obtain differential excitation cross sections, we normalized our data to the simultanously measured K-REC yield, using known K-REC cross sections. This type of normalization [2] is preferable because of the precision with which the K-REC cross sections are known and because of the good counting statistics. As an illustrative example, we quote in Tab. 1 the Lyman-α_1 cross sections in comparison with theoretical predictions. Here it can be seen, that our results are consistent with a fully relativistic first-order pertubation approach which considers the complete Liénard-Wiechert potential. The theory, which takes only the electrical part into account overestimates the experimental values by about 30%. Therefore, the results from the former experiment conducted for Bi (Z=83) are confirmed [1]. There, a destructive interference between the electric and magnetic part of the Liénard-Wiechert potential was observed for the first time.

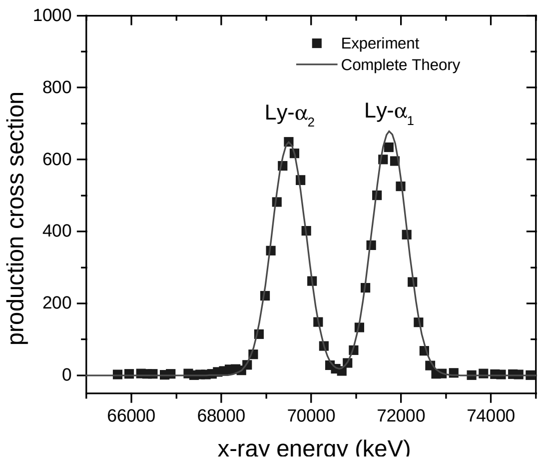

Fig. 1: Comparison of the experimental data (256 MeV/u $Au^{78+} \rightarrow Ar$) with the complete theoretical calculation, which considers the electric and the magnetic part of the Liénard-Wiechert potential. The Lyman-α_2 line was normalized to the theoretical line strength.

Table 1: Comparison of the experimentally measured Lyman-α_1 differential cross sections with the theoretical predictions for the collision of 256 MeV/u Au ions with gaseous argon.

Observation angle	Experiment (barn/ster)	Theory (barn/ster)	
		complete	Electric part
35°	55.8 ± 2.8	57.06	88.25
150°	54.9 ± 2.8	57.06	88.25

References

[1] Th. Stöhlker et al., Phys. Lett. A238, 43 (1998)

[2] Th. Stöhlker et al., Phys. Rev. A57, 845 (1998)

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