State-resolved KLL cross sections of single electron capture in collisions of swift $C^{4+}(1s2s\ ^3S)$ ions with gas targets

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Synopsis We report on the absolute cross sections determination for the production of the 1s2s2p ^4P and ^2P states via single electron capture in collisions of swift $C^{4+}(1s2s\ ^3S)$ ions with gas targets (H_2, He, Ne and Ar). The absolute cross sections were determined experimentally for all targets using high resolution Auger projectile spectroscopy, as well as theoretically for H_2 and He targets using ab initio calculations based on a three-electron close-coupling semiclassical approach.

In a recent publication [1] we reported on the formation of doubly excited triply open-shell $C^{3+}(1s2s2p\ ^{2,4}P)$ states via single electron capture (SEC) in collisions of swift $C^{4+}(1s2s\ ^3S)$ pre-excited ions with H_2 and He gas targets. Using high resolution Auger projectile spectroscopy and *ab initio* calculations based on a three-electron close-coupling (3eAOCC) semiclassical approach, we resolved a long-standing controversy on the value of the cross sections ratio $R=\sigma(^4P)/\sigma(^2P)$, used as a measure of spin statistics. Our findings invalidate the generally adopted frozen core approximation for the SEC process in multi-electron, multi-open-shell quantum systems and a new screening effect due to the Pauli exclusion principle (Pauli shielding) was proposed.

Here, we report on the determination of the absolute cross sections for the production of the ^4P and ^2P states via SEC in collisions of swift $C^{4+}(1s2s\ ^3S)$ ions with H_2 and He gas targets, as well as with Ne and Ar. The determination of the ratio R requires only relative electron yields and thus the corresponding absolute cross sections were not considered in [1].

The absolute cross sections were obtained experimentally after separating the contributions for the metastable 1s2s ^3S part of the $C^{4+}(1s^2\ ^1S, 1s2s\ ^{1,3}S)$ mixed-state ion beam, delivered by the tandem Van der Graaff accelerator. For this, we have developed a two-measurement technique [2] that exploits two independent spectrum measurements performed with ions having quite different 1s2s ^3S metastable fractions. In addition, the technique provides the value of the 1s2s ^3S metastable fraction that is necessary for the absolute cross section determination of the ^4P state.

The absolute cross sections were also determined within the 3eAOCC calculations [3] for the cases of H_2 and He. In the case of the long-lived ^4P state, selective cascade feeding from higher lying quartet states populated by SEC had to be considered [4].

A good agreement is evident both for H_2 and He targets. Moreover, the cross sections for Ne and Ar targets are shown to roughly scale with the number of electrons that can participate in the SEC process.

References

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We acknowledge support of this work by the project "Cluster of Accelerator Laboratories for Ion-Beam Research and Applications - CALIBRA" (MIS 5002799) implemented under the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).

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