Projectile electron spectroscopy: new answers to old questions

T. J. M. Zouros[1*†], I. Madesis[*†], A. Laoutaris [*†], E. P. Benis[‡]

[*]Department of Physics, University of Crete, P.O. Box 2208, GR 71003 Heraklion, Greece
[†]Tandem Accelerator Laboratory, INPP, NCSR Demokritos, GR 15310 Ag. Paraskevi, Greece
[‡]Department of Physics, University of Ioannina, GR 45110 Ioannina, Greece

Synopsis: Using a newly set up zero-degree Auger projectile electron spectroscopy apparatus we have investigated the production of $C^{3+}(1s2s2p\ ^{2,4}P)$ and $C^{4+}(2s2p\ ^{3,1}P)$ states in collisions of mixed $C^{4+}(1s2s\ ^{1,3}S, 1s^2)$ ions with H_2, He, Ne and Ar targets. The *1s2s2p* states are produced by capture to the *1s2s* component or transfer-excitation from the $1s^2$ with possible contributions from cascades and/or other excitation processes. The *2s2p* states are produced by direct 1s-2p excitation, electron-electron interaction plus spin exchange and/or transfer-loss processes. A new technique allows for the evaluation of the separate contributions of ground and metastable beam components, while strong differences between light and heavy targets help identify the active processes. Results to date are presented and discussed.

A zero-degree Auger projectile spectroscopy apparatus composed of a single stage hemispherical deflector analyzer with a four-element injection lens and a 2-dimensional position sensitive detector combined with a doubly differentially pumped gas target has been newly set up at the Demokritos 5.5 MV tandem accelerator for high resolution studies of electrons emitted from ions colliding with gas targets at 0°. Using this setup we have started a systematic isoelectronic investigation of projectile K-Auger electrons emitted from *pre-excited* He-like ions in collisions with dilute gas targets [1]. The goal is to study single electron capture to the He-like $(1s2s\ ^3S)$ metastable beam component [2, 3] and explore the effect of varying the metastable ^3S fraction [4] on the ratio R_m of the $^4P^o/(^2P_+ + ^2P_-)$ Auger KLL line intensities (see Fig. 1) of recent interest [5].

To obtain an independent cross check on the $C^{4+}(1s2s\ ^3S)$ metastable beam fraction, apart from the new method recently introduced [5] based on the analysis of the KLL lines in He-like beams with different metastable fractions, we have also explored the production of various Auger lines of slightly higher energy such as the He-like $2s2p\ ^{3,1}P$ KLL produced by 1s→2p excitation also shown in Fig. 1. These lines are of particular importance in the detailed study of fundamental excitation mechanisms [6], i.e. the electron-nucleus, and electron-electron excitation with spin exchange [7].

The presently unidentified lines in Fig. 1 are most likely due to $(1s2s\ ^3S)nl$ Li-like states [8] produced by direct *nl* capture (with *n=3-4*) to the metastable $1s2s\ ^3S$ beam component. Their existence constitutes further proof that these higher lying states are produced by capture as required by the proposed cascade mechanism [3, 5] leading to the observed enhancement of the ratio R_m [2, 3, 5]. Latest results on both excitation and capture and their dependence on the collision energy will be presented.

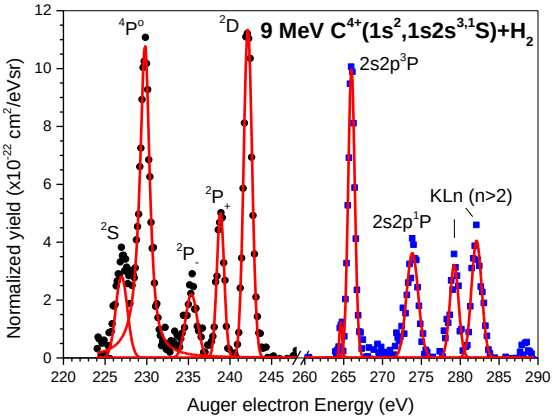

Figure 1. (Circles) $C^{3+}(1s2l2l')$ KLL, (squares) $C^{4+}(2s2p\ ^{3,1}P)$ KLL and $C^{3+}(1s2s\ ^3S)nl$ KLn (*n=3-4*) lines. The beam was produced by gas stripping in the accelerator terminal followed by gas *post*-stripping of the analyzed C^{3+} ions.

References

[1] I. Madesis *et al.* 2015 *J. Phys: Conf. Ser.* **583** 012014
[2] D. Strohschein *et al.* 2008 *Phys. Rev. A* **77** 022706
[3] T. J. M. Zouros *et al.* 2008 *Phys. Rev. A* **77** 050701
[4] E. P. Benis and T. J. M. Zouros, 2016 *J. Phys. B* **49** 235202
[5] D. Röhrbein *et al.* 2010 *Phys. Rev. A* **81** 042701
[6] D. H. Lee *et al.* 1991 *Nucl. Instrum. & Meth. Phys. Res. B* **56/57** 99
[7] T. J. M. Zouros *et al.* 1989 *Phys. Rev. Lett.* **62** 2261
[8] J. P. Santos *et al.* 2017 *Nucl. Instrum. & Meth. Phys. Res. B* in press.

[1]E-mail: tzouros@physics.uoc.gr