Investigation of 2s2p 3P excitation and (1s2s 3S)nl capture lines in 6-18 MeV C4+ (1s2, 1s2s 3S) collisions with gas targets

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Synopsis
A zero-degree Auger projectile spectroscopy apparatus composed of a single stage hemispherical deflector analyzer with a four-element injection lens and a two-dimensional position sensitive detector combined with a doubly differentially pumped gas target has been newly set up at the Demokritos 5.5MV tandem accelerator in Athens for high resolution studies of electrons emitted from ions colliding with gas targets. Using this setup (see Fig. 1) 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 study single electron capture to the He-like (1s2s 3S) metastable beam component and the effect of varying the metastable fraction [2] and the dependence of the ratio of 4P/4S Auger KLL line intensities due to capture to the 1s2s 3S of recent interest [3].

To obtain an independent cross check on the C4+(1s2s 3S) metastable beam fraction, apart from the new method recently introduced [4] on the analysis of the KLL lines in He-like beams with different metastable fraction, we have also explored the production of various Auger lines of slightly higher electron energy such as the He-like 2s2p 1P KLL produced by 1s-2p excitation shown in Fig. 2. These lines are also of particular importance in the detailed study of fundamental mechanisms of excitation [5], i.e. the electron-nuclear, electron-electron and electron-electron excitation with spin exchange [7].

The presently unidentified lines in Fig. 2 are most probably due to (1s2s 3S) Li-like states [6] produced by electron impact excitation and (1s2s 3S) Li-like capture as a result from the 1s2s 3S beam component. Their existence would be further proof that these higher lying states are produced by capture as required by the proposed cascade feeding mechanism [3,5] leading to the observed enhancement of the metastable fraction [2].

Latest results on these excitation and capture cross sections and their dependence on the collision energy are presented.

Fig. 1: Photograph of the APAPES beam line dedicated for atomic collisions physics research showing the various parts of the apparatus. From left to right: the focusing quadrupole (1), a pair of magnetic steerers (2), a beam profile monitor (3), the differentially pumped gas cell target (4) inside a six-way cross and the chamber containing the electrostatic Hemispherical Deflector Analyzer (HDA) (5). On the left, some of the HV voltage precision power supplies (6) used to bias the HDA can be seen.

Fig. 2: Electron spectrum from 9 MeV C4+(1s2, 1s2s 3S) collisions with He. Auger Lines: (black squares) C4+(1s2s 3S) KLL (blue circles) C4+(2s2p 1P) KLL and C4+(2s2s 3S) KLL (red triangles). C4+(1s2s 3S) beam was produced by gas stripping in the accelerator terminal and subsequent gas post stripping of the analyzed C4+ ions. An average value of the C4+(1s2s 3S) beam fraction f = (1s2s 3S)/(1s2s 3S) defined from experimental data is determined to be 20%.

Fig. 3: Electron spectra from 9-18 MeV C4+(1s2, 1s2s 3S) collisions with He. Auger lines: (blue circles) C4+(2s2p 1P) KLL and C4+(1s2s 3S) KLL (n=3-4). The C4+ beam was produced either by foil stripping in the accelerator terminal (11-18MeV) or by gas stripping in the accelerator terminal and subsequent gas post stripping of the analyzed C4+ ions (9MeV). An average value of the C4+(1s2s 3S) beam fraction f is determined to be 20%. The cross sections of the C4+(2s2p 1P) KLL and C4+(1s2s 3S) KLL (n=3-4) appear to depend strongly on the collision energy, particularly obvious at the lower (9-11 MeV) collision energies. Note the open blue circles (Q) have been scaled by a factor of 5 to facilitate viewing.

Fig. 4: 2s2p 1P Auger electron production cross sections as a function of the collision energy. An average overall metastable beam fraction f=20% was assumed. A big change in the production cross sections can be observed at collision energies lower than ~10 MeV.

Conclusions – Future projects

- A strong dependence of the C4+(2s2p 1P) KLL and C4+(1s2s 3S) KLL (n=3-4) production cross sections on the collision energy was observed which will be further investigated at lower energies in the near future.
- The production cross sections C4+(2s2p 1P) KLL and C4+(1s2s 3S) KLL (n=3-4) dependence on the stripping medium (foil or gas) for the same collision energy appears interesting and will be further investigated in the future. In this way, we expect to separate the contributions of the 1s2 1S or 1s2s 1S states to the production of the 2s2p 1P states.

REFERENCES

Acknowledgement
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* Co-financed by the European Union (European Social Fund—ESF) and Greek national funds through the Operational Program “Education and Lifelong Learning” of the National Strategic Reference Framework (NSRF)
— Research Funding Program: THALES. Investing in knowledge society through the European Social Fund (Grant No. MIS 377289).