Production of 2s2p $^{3,1}P$ excitation lines in 6-18 MeV C^{4+} ($1s^2$, 1s2s ^3S) collisions with He: experiment and calculations

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Abstract

A zero-degree Auger projectile spectroscopy (ZAPS) apparatus dedicated to high resolution Auger electron spectroscopy studies has recently been setup at the Demokritos 5.5 MV tandem accelerator. Using this ZAPS setup we have initiated a systematic isoelectronic investigation of projectile K-Auger electrons emitted from *pre-excited* He-like ions in collisions with dilute gas targets [1]. One of our research goals is to study the formation mechanisms of the 2s2p $^{3,1}P$ states. These lines are of particular importance in the detailed study of fundamental excitation mechanisms [2,3], i.e. electron-nucleus, electron-electron and electron-electron excitation with spin exchange.

So far, we have obtained the collisional energy dependence of the total excitation cross sections of the 2s2p $^{3,1}P$ states. Typical measurements of high resolution Auger spectra are shown in Fig. 3. Our latest cross section results are presented in Fig. 4.

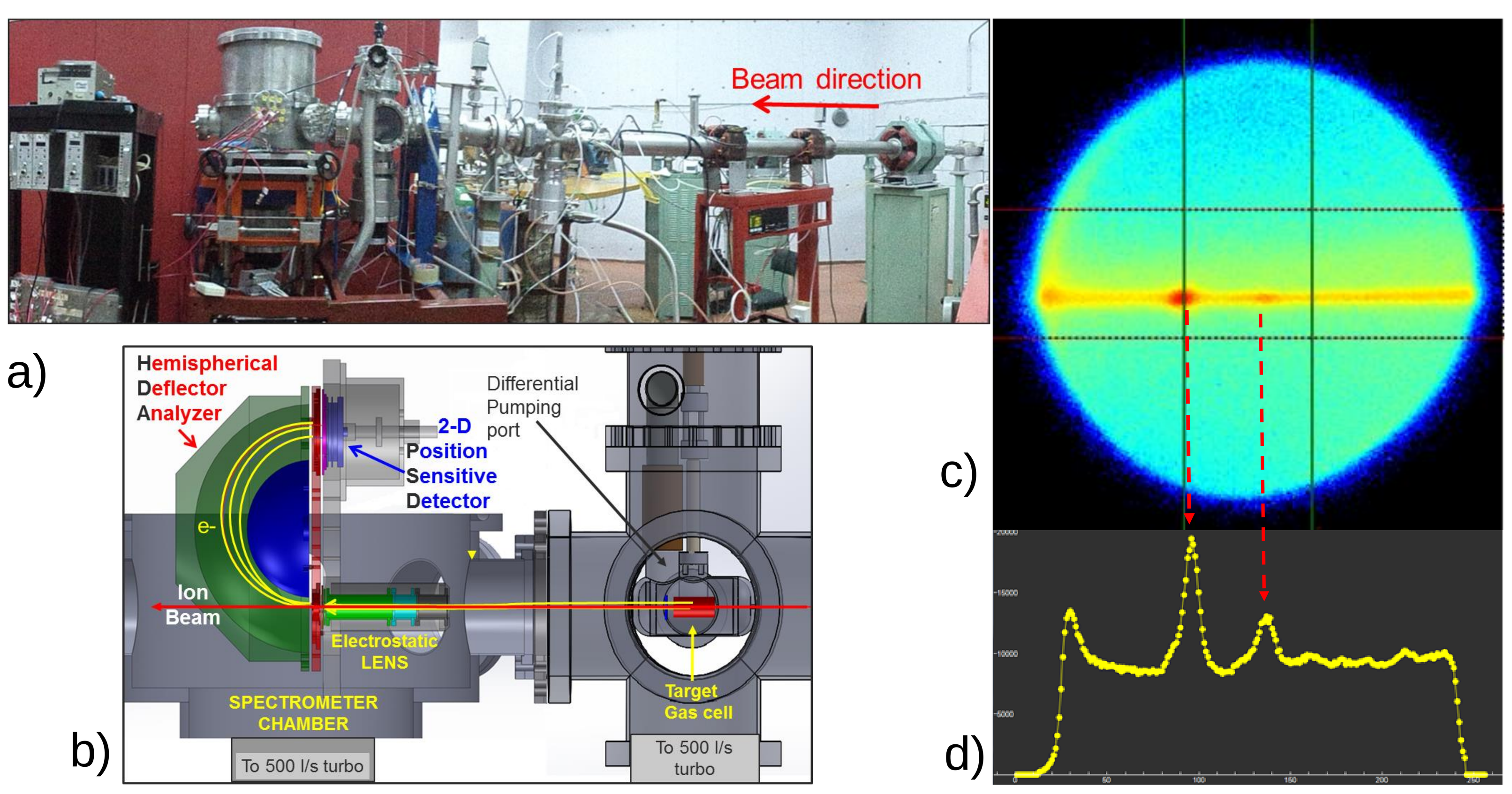

Fig. 1: a) Photo of the dedicated beamline for Atomic Physics research at the NCSR "Demokritos" Tandem laboratory. b) Schematic of the gas target, spectrometer (Hemispherical Deflector Analyzer, HDA) with position sensitive detector (PSD). c) 2-D image of the detected Auger electrons on the PSD. d) Projection along the energy axis of the PSD image indicating the 2s2p $^{3,1}P$ lines.

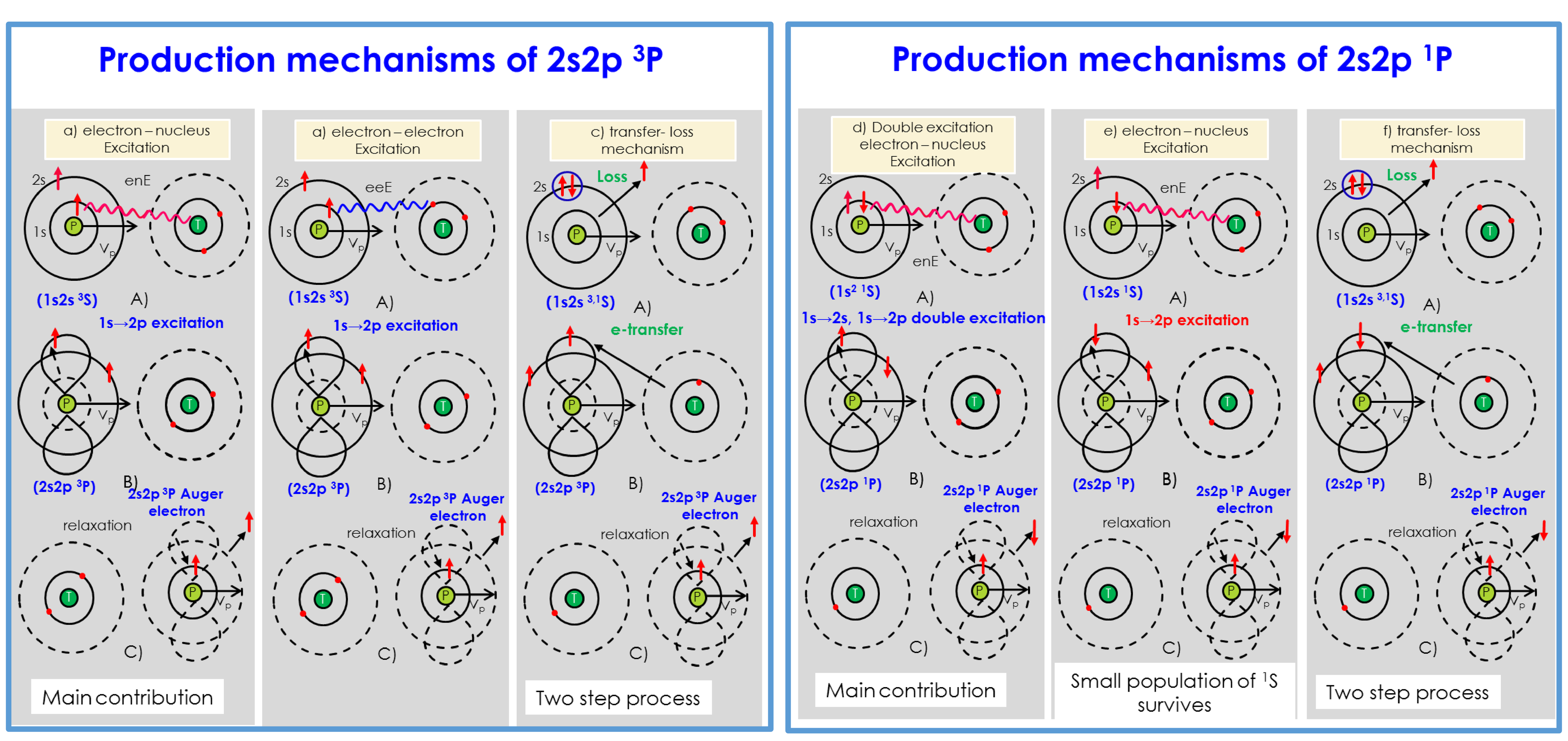

Fig. 2: Schematic of some of the active processes studied during collisions between He-like ionic projectiles (P) and atomic targets (T) leading to the formation of 2s2p $^{3,1}P$ states which can be detected via their strong Auger decay [2]. The initial electron configuration of the ion beam plays the main role in determining which processes may follow. For the formation of 2s2p ^3P the main processes are: direct 1s-2p excitation from the 1s2s ^3S initial state via either (a) electron – electron interaction (eeE) or (b) projectile electron – target nucleus interaction (enE) excitation with spin exchange from 1s2s ^1S state (c) Transfer – loss mechanism. For the formation of 2s2p ^1P the main processes are: d) double excitation from ground state $1s^2$, e) electron – nucleus excitation from 1s2s ^1S excited state, f) Transfer - loss mechanism.

6 -18 MeV C^{4+} ($1s^2$, 1s2s $^{3,1}S$) +He

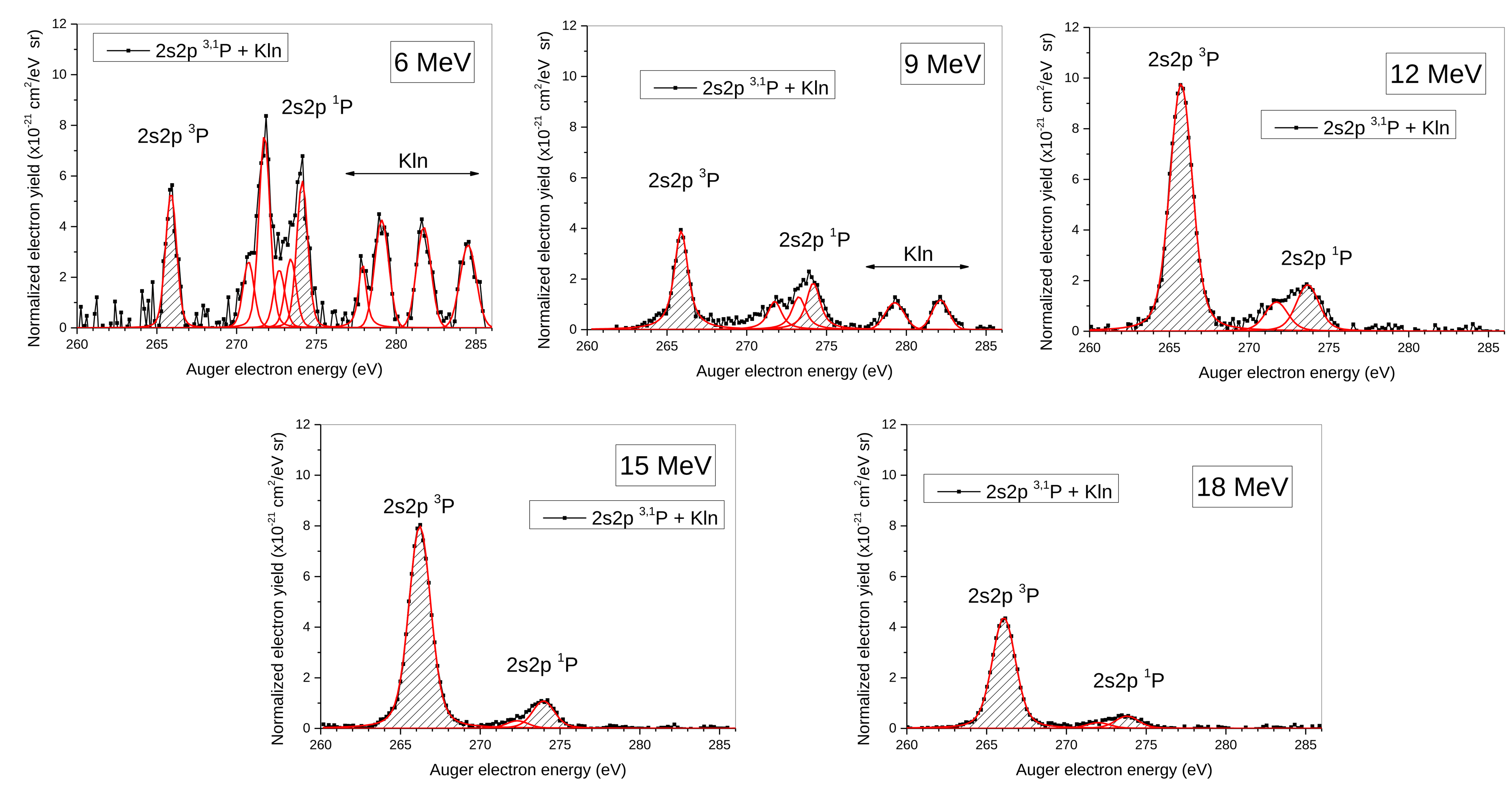

Fig. 3: Measured C^{4+}(2s2p $^{3,1}P$) KLL and C^{3+}(1s2s ^3S) nl KLn (n=3-4) Auger lines. The C^{4+} beam was produced by gas stripping in the accelerator terminal followed by gas post-stripping of the analyzed C^{3+} ions

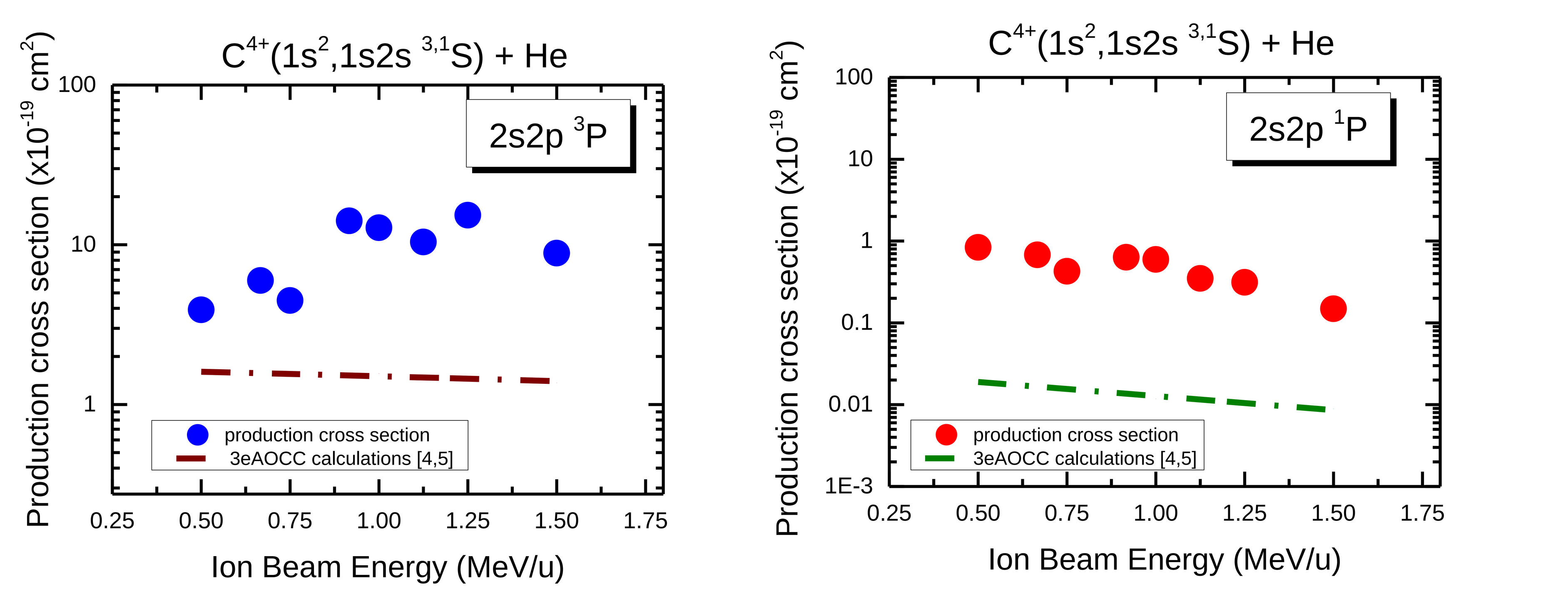

Fig. 4: Experimental production cross sections of 2s2p ^3P (left) and 2s2p ^1P (right) together with theoretical calculations by A. Dubois (2018) [4,5]. In the theoretical calculations it is assumed that only the 1s2s ^3S contributes to the formation of the 2s2p ^3P population, while for the formation of the 2s2p ^1P only contribution from the $1s^2$ ground state is taken into account. The difference with experiment can possibly be explained if we also take into account the contribution from the small 1s2s ^1S component of the beam. In addition, possible cascades from higher lying states might also be important and presently also under investigation

Conclusion and future work

- A detailed investigation of 2s2p $^{3,1}P$ lines has been performed so far in the region of 6-18MeV collision energies together with theoretical calculations [5].
- Further investigation of the origin and mechanisms leading to the formation of the 2s2p $^{3,1}P$ lines using additional targets such as H_2, Ne and Ar need to be done.
- Try to define more accurately the contribution from the different components of the ion beam.
- Continue an isoelectronic study using additional He-like ion beams (Li^+, B^{3+}, N^{5+}, O^{6+}, F^{7+})

References

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