Coherent treatment of transfer excitation processes in swift ion-atom collisions

E. P. Benis[1], T. J. M. Zouros[2,3], A. Laoutaris[2,3], I. Madesis[2,3], S. Nanos[1,3],
S. Passalidis[4] and A. Dubois[4]

[1]Department of Physics, University of Ioannina, GR-45110 Ioannina, Greece
[2]Department of Physics, University of Crete, GR-70013 Heraklion, Greece
[3]Tandem Accelerator Laboratory, Institute of Nuclear and Particle Physics,
NCSR "Demokritos", GR-15310 Ag. Paraskevi, Greece
[4]Sorbonne Université, CNRS, Laboratoire de Chimie Physique-Matière et Rayonnement,
F-75005 Paris, France

For more than 40 years since the first ion-atom collision investigations of the two-electron process of electron transfer with excitation (TE) and its resonant (RTE) and non-resonant (NTE) features, a satisfactory quantum mechanical treatment has been lacking. Here, we present the first such comprehensive TE treatment using a three-electron close-coupling approach, exemplified by $C^{4+}(1s^2)$ + He collisions at 0.5-18 MeV impact energies.

We focus on the production of the $C^{3+}(1s2p^2\ ^2D)$ state, which shows the strongest TE resonance amongst the KLL states. Single differential cross sections (SDCS) are experimentally determined using zero-degree Auger projectile spectroscopy (ZAPS), by detecting the emitted Auger electron at $\theta=0^o$ with respect to the beam direction. Our recently proposed "two-spectra measurement" *in situ* technique [1] was applied to separate the $C^{4+}(1s^2)$ ground state contributions from the delivered $C^{4+}(1s^2,\ 1s2s\ ^3S)$ mixed-state beam. Our theoretical treatment considers, for the first time, the dynamics of three active electrons using semiclassical close-coupling calculations within a full configuration interaction approach [2]. This implementation allows for a coupled and coherent treatment of all processes such as target and projectile excitation, ionization, single electron capture [3], as well as TE and therefore goes well beyond past methods.

The calculated single differential cross sections are found to be in excellent agreement with the ZAPS measurements at the high impact energies between 6-18 MeV where RTE is prominent. At the lower energies, 0.5-6 MeV, a second maximum is observed in the theoretical results but could not be recorded experimentally due to low beam currents provided by our facilities in this regime. The low energy structure is interpreted through a new nonresonant correlated mechanism, never considered to date. In the conference, detailed information, such as transition probabilities as a function of impact parameter and energy, will be presented to illustrate the different features of the two mechanisms exposed in our results.

References

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