§7. Theoretical Study of Electron Transitions in Slow Collisions of Ions with He

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In theoretical studies of electron transitions in slow ion-atom collisions, the close-coupling method is established [1] as reliable and flexible. Many features of the collisions, once guessed from intuitive physical pictures, can be investigated quantitatively by choosing appropriate basis sets for the time-evolution of the electron wavefunction.

We have set out to investigate electron transfer, excitation, as well as two-electron transitions in He^{2+}, Be^{4+}, C^{6+} – He collisions in the energy range 1 – 100 keV/u. With large basis sets of atomic orbitals including pseudostates, we aim at the prediction of cross sections for the population of specific final states. Information on all these processes is needed for charge exchange and beam emission plasma diagnostics methods which are in wide use at fusion facilities. It also contributes to a quantitative understanding of processes in the plasma edge region. This work is conducted in close contact with the needs of the experimental programme at JET, Culham, England, and with related laboratory experiments at Groningen, The Netherlands.

For the investigation of He^{2+} – He collisions, electron transfer and transfer-excitation channels are included up to the $n = 4$ shell of, respectively, the projectile and the target. Double-electron capture and single-excitation channels are included up to the $n = 3$ shells. A close analysis of the electron dynamics in slow collisions as well as the numerical results show that partial single-transfer and transfer-excitation cross sections to a given state in the target and in the projectile are about the same. This is, at first sight, a surprising feature since the two-electron process of transfer excitation is generally weak. In this *symmetric* collisions system, however, the distinction between target and projectile is lost in slow collisions. We illustrate this point in a plot of the calculated and measured 4–3 line emission cross section ratios, see Fig. 1.

Work on this system has been completed. A full account is given in a forthcoming publication [3].

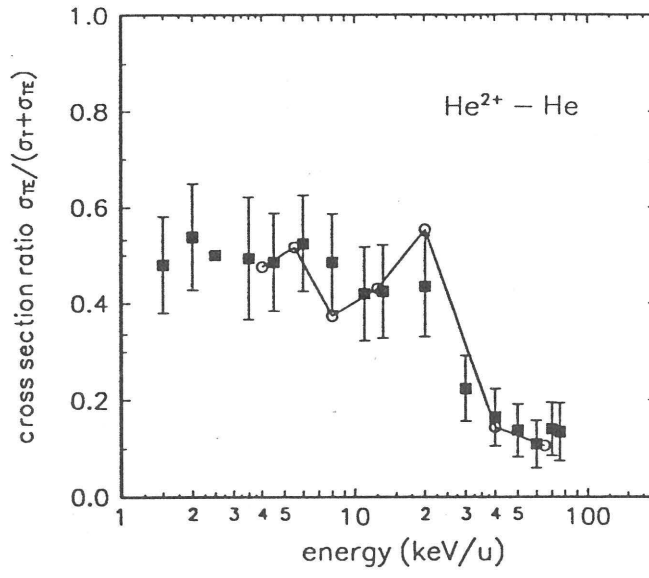

Fig. 1. Ratio of 4–3 line emission cross sections, in He^{2+}–He collisions, from the target (transfer-excitation) to the cross sections from both target and projectile (single transfer *and* transfer-excitation). Shown are results from this work (line) and recent data [2] from Groningen.

Calculations on the systems of Be^{4+}, C^{6+} – He are in progress. Here we include the single-transfer channels of up to $n = 7$, the single excitation channels to the $n = 2$ states of He, as well as the most important transfer-excitation and double-transfer channels. This work has led to an assessment of the scaling properties, with respect to the projectile charge state, of transfer-excitation cross sections [4].

The calculations within this work have been performed in part on a HP Apollo 735 workstation which is operated by NIFS Nagoya. We are indebted to the staff of the Computer Center for technical support. Partial financial support by JET is also gratefully acknowledged.

References

[1] Fritsch, W., Lin, C.D., Phys. Rep. 202 (1991) 1.
[2] Folkerts, H.O., *et al*, J. Phys. B 26 (1993) L619.
[3] Fritsch, W., J. Phys. B (1994) in press.
[4] Fritsch, W., Phys. Lett. A (1994) in press.