§17. One Electron Capture Cross Sections in Highly Charged Ion-Atom Collisions

Yamada, I., Sakaue, H. A., Tawara, H.
Hosaka, K. (Grad. Univ. Adv. Studies)
Krok, F. (Inst. Phys. Jagiellonian Univ.)
Nakamura, N., Watanabe, H., Ohtani, S., (Inst. Laser Sci. Univ. Electro-Communications)
Danjo, A. (Dept. Env. Sci. Niigata Univ.)
Yoshino, M. (Shibaura Inst. Tech.)
Sakurai, M. (Inst. Mol. Sci.)
Kimura, M. (Kochi Inst. Tech.)
Matsumoto, A. (Hiroshima Inst. Tech.)

Electron capture collisions of slow, highly charged ions with atoms or molecules are most important processes in edge and diverter plasmas. Therefore, the reliable cross section data and simple scaling formulae are strongly required for understanding and modeling the plasmas.

We have measured absolute cross sections for total and one electron capture processes in 1.5q keV I^{q+} ($6 \leq q \leq 30$)-rare gas atoms (Ne, Ar, Kr and Xe) and simple molecules (H_2, D_2, N_2, CO, CO_2 and CH_4). Incident I^{q+} ions are produced with NICE. The measurements were carried out by using the growth rate method combined with the modulated retardation potential technique. Experimental uncertainties are estimated to be less than ±20 %.

The scaling formula for total capture cross sections has been already reported [1]. Here, a scaling relation for one electron capture processes is described. The scaling equation is based on that proposed by Müller-Saltzborn [2], and given by,

$$\sigma^{1cap} = Aq^{\alpha}P^{\beta} \qquad (1)$$

where q is the initial charge state and P is the first ionization energy of target species. The relation is very useful for its simplicity and similarity to the scaling for total cross sections. It is noted that the original Müller-Saltzborn scaling is known to be valid only for low charge states ($q \leq 5$) or light targets as Ne. We have now determined the scaling parameters by fitting eq.(1) to our data, resulting in A=117, a=0.90 and b=-1.66 when σ^{1cap} and P are expressed in 10^{-15} cm^2 and eV, respectively.

The comparison between the scaling formula and data is shown in Figure 1 and 2 for atomic and molecular targets, respectively. The newly determined scaling formula is found to well reproduce our data for both atomic and molecular targets within ±14% (broken lines). It is noted that the scaling formula is expected to be valid for slow collisions below v~1 a.u., as in the case for total cross sections.

More systematic analysis including all existing data are now in progress.

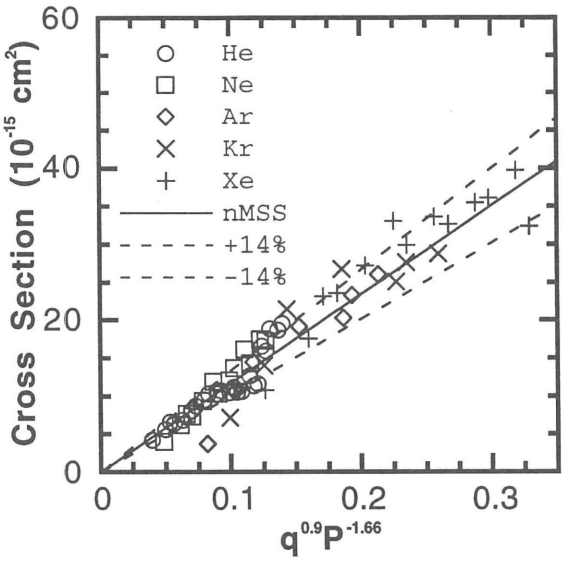

Fig. 1. One electron capture cross sections in I^{q+}-He, Ne, Ar, Kr and Xe collisions. The solid line shows the modified Müller-Saltzborn scaling.

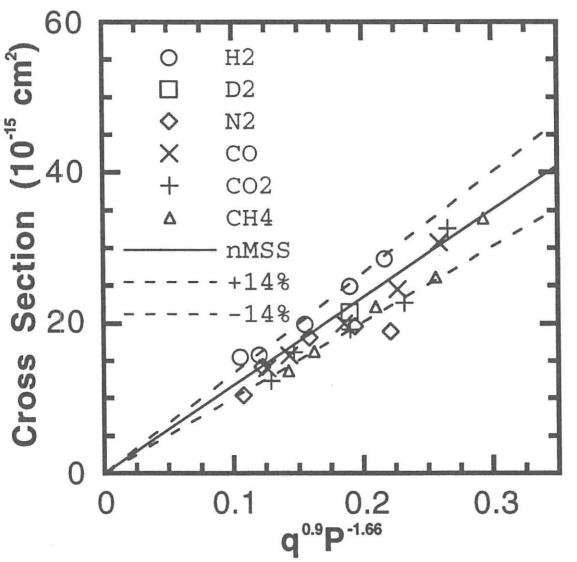

Fig. 2. One electron capture cross sections in I^{q+}-H_2, D_2, N_2, CO, CO_2 and CH_4 collisions. The solid line shows the modified Müller-Saltzborn scaling.

References

1) M. Kimura *et al.*, J. Phys. B 28, L643 (1995).
2) A. Müller and E. Saltzborn, Phys. Lett. 62A, 391 (1977).