Screening effect on multiple ionization of Ar_2 by highly charged ions

T. Ohyama-Yamaguchi[1] and A. Ichimura[2]

[1] *Tokyo Metropolitan College of Industrial Technology, Tokyo 140-0011, Japan*
[2] *Institute of Space and Astronautical Scinece, JAXA, Sagamihara 252-5210, Japan*

Presenting Author: yamaguti@s.metro-cit.ac.jp

Much attention has been called to the Coulomb explosion of molecules in collisions with slow (velocities of $v \ll 1$ atomic unit) highly charged ions. Recent progress of multiple coincidence techniques permits us to measure the dissociating ion pair distribution produced in the collisions. Such findings are of great interest from the viewpoint of multi-center multi-electron dynamics. In contrast with covalent molecules, however, little effort has been devoted to rare gas dimers.

About ten years ago, we proposed a three-center Coulombic over-barrier model to describe sequential multiple ionization of rare gas dimers [1]. In a recent work [2] we modified the model so as to incorporate the effect of partial screening for non-active target atomic site (B or C) in respective steps of electron removal during a collision. The measured result [3] of ion pair distribution up to four electron removal in $Ar^{9+} + Ar_2$ collisions was best reproduced with the model by taking a screening parameter of $s = 0.4$ (see figure 1).

In the present work, we further consider the screening effect for the projectile ion A^{q+} so as to make a consistent framework. The three charges in the three center Coulomb potential

$$U(\boldsymbol{r}) = -\frac{q_A}{|\boldsymbol{r} - \boldsymbol{R}_A|} - \frac{q_B}{|\boldsymbol{r} - \boldsymbol{R}_B|} - \frac{q_C}{|\boldsymbol{r} - \boldsymbol{R}_C|}$$

are effectively taken as

$$\begin{aligned} q_A &= q - (Q_B + Q_C)(1 - s) \\ q_B &= Q_B + 1, \\ q_C &= (1 - s)Q_C \end{aligned}$$

for the active electron at site B, and

$$\begin{aligned} q_A &= q - (Q_B + Q_C)(1 - s) \\ q_B &= (1 - s)Q_B, \\ q_C &= Q_C + 1 \end{aligned}$$

for the active electron at site C.

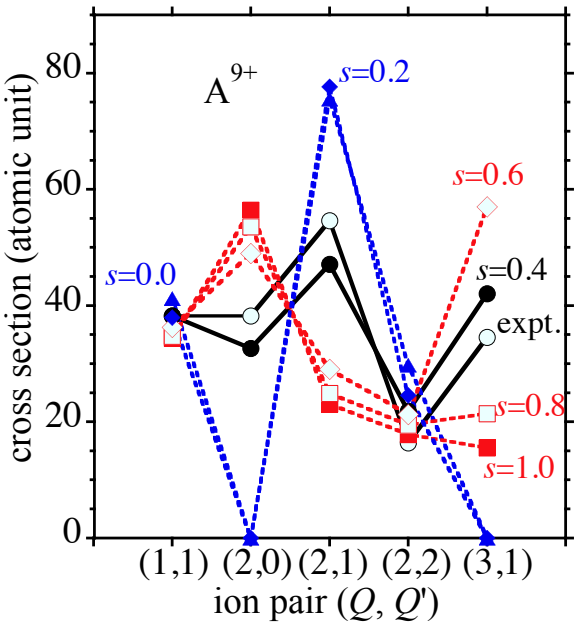

Figure 1: *Dependence of the ion pair (Q, Q') formation cross sections on the parameter s for the collisions of $A^{9+} + Ar_2$, where the screening effect is introduced only in the target.*

It was found that the projectile screening effect is noticeable in the population of highly charge-asymmetric pairs such as $(Q, Q') = (2, 0)$ and $(3, 1)$. We have also analyzed the collisions of $Xe^{20+} + Ar_2$ and found that the measured ion-pair distribution [4] could be reasonably reproduced with $s \simeq 0.6$. The physical meaning of this result is discussed.

References

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