

Scaling for state-selective charge exchange due to collisions of multicharged ions with hydrogen

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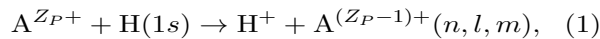
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Synopsis State-resolved charge exchange (CX) cross sections for Be⁴⁺, C⁶⁺, N⁷⁺ and O⁸⁺ projectiles colliding with atomic hydrogen are evaluated employing two different methods: the Classical Trajectory Monte Carlo (CTMC) and the eikonal impulse (EI) approximations. These cross sections are used to extend previously derived scaling laws for $n-$, $nl-$, and $nlm-$ distributions to highly excited final levels with $4 \leq n \leq 9$, covering energies in the range 50–2000 keV/amu. Present results are in agreement with available experimental and theoretical data for these collision systems, becoming a useful instrument for plasma research.

As reported in Ref. [1], it is possible to use the prior EI approach to derive a scaling rule for the following reaction:



using that the corresponding CX cross section, σ_{nlm} , nearly satisfies:

$$\sigma_{nlm}^{EI} \simeq \tilde{z}_P^{-7} |C(Z_P/v)|^2 u_{nlm}(\tilde{W}), \quad (2)$$

where v is the impact velocity, $\tilde{z}_P = Z_P/v$, and $C(Z_P/v)$ is the Coulomb factor coming from the asymptotic conditions. In Eq. (2) the function u_{nlm} can be considered as an universal function of the scaled transferred momentum $\tilde{W} = (\tilde{v}^2 + \tilde{z}_T^2 - 1)/(2\tilde{v})$, with $\tilde{z}_T = Z_T/\tilde{z}_P$ ($Z_T = 1$ for H) and $\tilde{v} = v/\tilde{z}_P$.

Two different approximations, EI [1] and CTMC [2], are used to evaluate state-selective CX cross sections for Be⁴⁺, C⁶⁺, N⁷⁺, and O⁸⁺ projectiles impinging on H(1s), considering a different velocity range for each method: $v = 1 - 3$ a.u. for the CTMC approach and $v = 2 - 10$ a.u. for the EI one. The fact that there is a velocity region where both approaches can be successfully applied allows us to provide reliable scaling rules that cover a wide range of incidence energies.

In Fig. 1 we display scaled CX cross sections into the final level n , $S_n = \tilde{z}_P^7 \sigma_n / |C(Z_P/v)|^2$, as a function of \tilde{W} , including CTMC and EI results for $n = 4 - 9$. The proposed scaling makes it possible to gather all the results in a relatively narrow band. Similar behavior is also obtained for the nl -distributions, defined as $P_{nl} = \sigma_{nl}/\sigma_n$, when they are plotted as a function of \tilde{W} , as shown in Fig. 2.

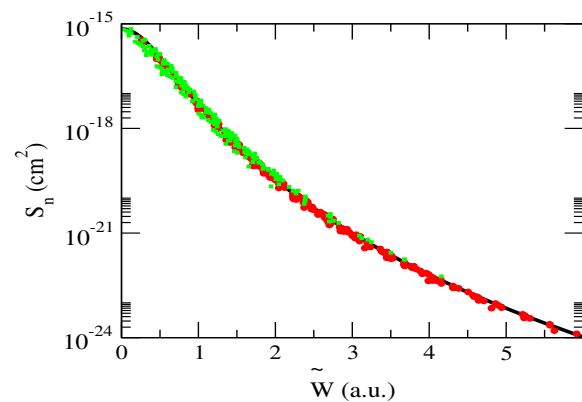


Figure 1. Scaled cross sections S_n in the range $n = 4 - 9$, evaluated with the considered approaches: • EI, ■ CTMC.

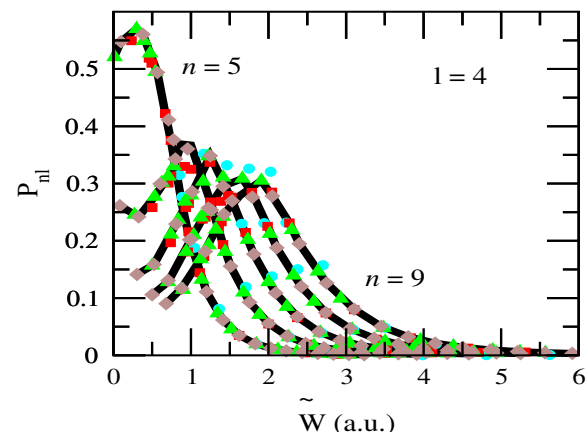


Figure 2. Joined CTMC and EI distributions for $l = 4$, as a function of \tilde{W} , considering different projectiles: • Be⁴⁺, ■ C⁶⁺, ▲ N⁷⁺, ◆ O⁸⁺.

References

- [1] M. S. Gravielle, J. E. Miraglia 1995 *Phys. Rev. A* **51** 2131–2139, ibidem **52** 851–854
- [2] Clara Illescas, A. Riera 1999 *Phys. Rev. A* **60** 4546–4560

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