4 - 2 Benchmark $n\ell$-resolved Cross Sections of Single and Double Charge Exchange Processes in Slow C^{4+}+He Collisions*

Guo Dalong[1,2], Zhang Ruitian[1,2], Zhu Xiaolong[1,2], Gao Yong[1,2], Lin Kaizhao[3,1], Cao Ting[1,2], Zhao Dongmei[1,2], Zhu Xubin[1,2], Zhang Chijun[1,2], Zhang Shaofeng[1,2] and Ma Xinwen[1,2]

([1]Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China;
[2]University of Chinese Academy of Sciences, Beijing 100049, China;
[3]University of Science and Technology of China, Hefei 230026, Anhui, China)

X-ray and extreme-ultraviolet (EUV) emissions have been detected from many comets. It is now recognized that the charge exchange (CX) mechanism between highly charged solar wind ions and cometary neutrals is responsible for the observed emissions. State-resolved CX cross sections are of the utmost importance for modeling related photon emissions.

With the cold-target recoil-ion momentum spectroscopy, the state-resolved cross sections for both single electron capture (SEC) and double electron capture (DEC) occurring in 1.67∼20 keV/u C^{4+} + He collisions were determined at the quantum orbital angular momentum level (Fig. 1), which provides the most stringent test of the various CX theories and allows one to assess different CX models widely adopted by the astrophysical community. It was found that the most recent semiclassical atomicorbital close-coupling (SCAOCC) method was almost perfect in the predictions of the present measurements at a quantum orbital angular momentum level. In contrast, it was found that all the existing analytical models to describe CX in astrophysical observations, like separable, even, low-energy, and statistical models, are insufficient to describe the ℓ distributions for the system considered. The present results indicate that the applicability of these models should be collision velocity and collision partner species dependent, and the electronic correlations for multielectron processes cannot be neglected.

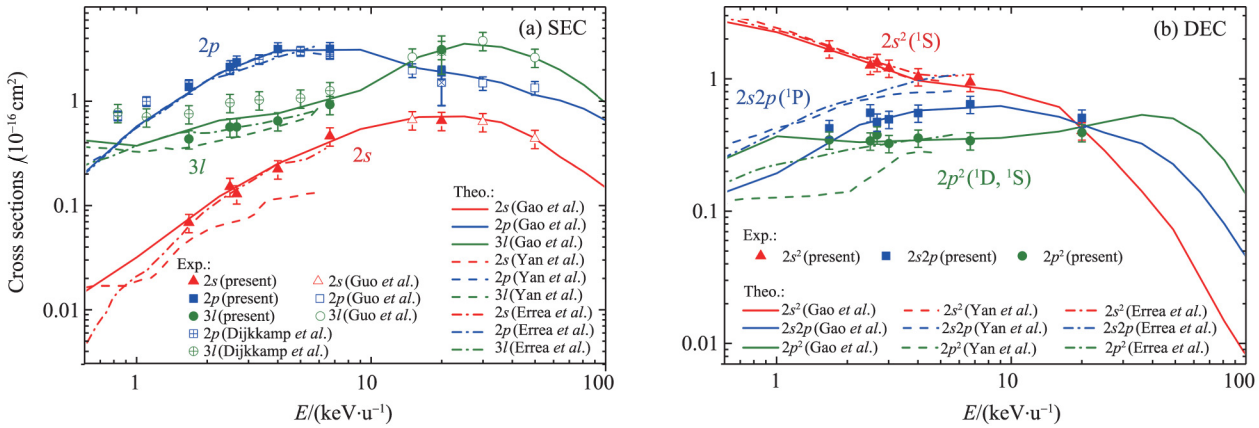

Fig. 1 (color online) The absolute state selective cross sections as a function of impact energy for SEC and DEC in collisions of C^{4+} with He. Experiments: present measurements (solid symbols); Guo, *et al.*[1] (opened symbols) and Dijkkamp, *et al.*[2] (crossed symbols); Theories: Gao *et al.*[3] (solid lines), Yan *et al.*[4] (dashed lines) and Errea, *et al.*[5] (dot-dashed lines).

The present experimental data are of direct relevance for understanding the effects of the solar wind interacting with at comets as well as other planets once X-ray calorimeters become available in the future.

References

[1] D. L. Guo, Y. Wu, N. Sisourat, et al., Phys. Rev. A, 103(2021)032827.
[2] D. Dijkkamp, Dijkkamp, E. Vileg, et al., J. Phys. B, 18(1985)4763.
[3] J. W. Gao, Y. Wu, N. Sisourat, et al., Phys. Rev. A, 96(2017)052703.
[4] L. L. Yan, Y. Wu, Y. Z. Qu, et al., Phys. Rev. A, 88(2013)022706.
[5] L. F. Errea, B. Herrero, L. Mendez, et al., Phys. Rev. A, 28(1995)693.

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