Benchmark Measurements of State-selective Charge Exchange Processes in Slow Ion-atom Collisions

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Synopsis The state-resolved cross sections for both single electron capture and double electron capture occurring in 1.67-20 keV/u C^{4+} + He collisions were determined at the quantum orbital angular momentum level using the COLTRIMS technique, 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.

State-resolved charge exchange (CX) cross sections are of the utmost importance for modeling related photon emissions existing in a broad range of astrophysical environments. 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, 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 semi-classical atomic-orbital close-coupling (SCAOC-C) method was almost perfect in the predictions of the present measurements at a quantum orbital angular momentum level. In contrast, 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. The present work reveals that the velocity and collision partner species dependence effects as well as electronic correlations for multi-electron processes should be included in an improved model. Alternatively, in future modeling to interpret high-resolution astrophysical observations the more elaborate quantum-mechanical calculations may be resorted to with confidence.

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

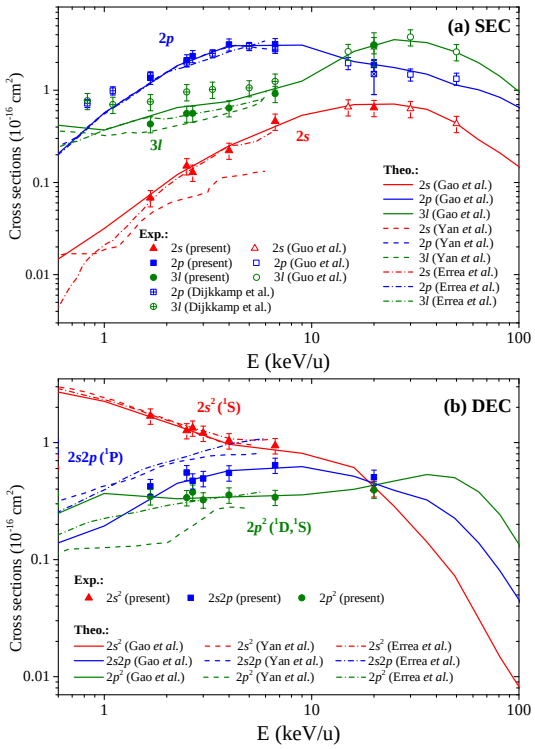

Figure 1. The absolute state selective cross sections. Experiments: present measurements (solid symbols); Guo *et al.* [1] (opened symbols) and Dijkkamp *et al.* [2] (crossed symbols); Theories: Gao *et al.* [3] (solid lines), Yan *et al.* [4] (dashed lines) and Errea *et al.* [5] (dot-dashed lines).

References

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