X-ray emission from highly-charged ions after electron transfer in slow collisions: the role of multiple capture processes

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X-ray emission from highly-charged ions after electron transfer in slow collisions: the role of multiple capture processes

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Synopsis We have studied 15 keV/q Ar^{17+} impact on atomic Ar experimentally and theoretically. Our analysis shows that multiple capture processes followed by autoionization contribute strongly to the measured Lyman X-ray emission intensities in the heliumlike projectile.

The dominant process in low-energy ion-atom collisions is electron transfer. If the projectile is highly charged, multiple capture is possible and multiply excited projectile states can be formed. This gives rise to a complex de-excitation cascade that involves both Auger and radiative transitions. Unless one would do a "complete experiment" that measures all relevant photon and ion charge state coincidences (and possibly Auger electrons as well) it is difficult to obtain complete information on such a collision system from measurements alone. Similarly, the predictive power of theoretical calculations is limited simply because a full first-principles calculation of the many-electron dynamics is not feasible.

We have investigated 15 keV/q Ar^{17+}-Ar collisions both experimentally and theoretically. The experiments make use of low- and high-resolution X-ray spectroscopy and resolve the whole heliumlike Ar^{16+} Lyman series from $n = 2$ to $n = 10$ [1].

The theoretical calculations are based on the assumption that the collisional capture and the post-collisional Auger and radiative decays can be viewed as being independent. The capture calculations are carried out on the level of the independent electron model using the two-center basis generator method (TC-BGM) and including projectile states up to the 10th shell in the basis [2]. The cross sections obtained for shell-specific multiple capture are fed into an Auger decay scheme [3]. This yields n-specific cross sections for *apparent* single capture that together with the *actual* single capture cross sections are then fed into a radiative cascade code to obtain X-ray emission intensities that can be compared with the experimental data. Likewise, we can feed only the actual single capture cross sections into that code to obtain intensities that correspond to the assumption that multiple capture does not contribute.

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Figure 1 shows our main result. For $n \geq 7$ multiple capture is negligible and both sets of theoretical intensities coincide. They are at variance with the experimental data for $n = 8$ and $n = 10$, possibly because of the limited basis set used in the TC-BGM calculations.

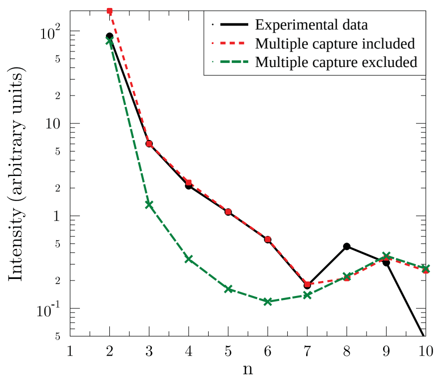

Figure 1. Experimental and calculated X-ray intensities for $1snp \rightarrow 1s^2$ transitions in Ar^{16+} following electron capture in 15 keV/q Ar^{17+}-Ar collisions (see text for details).

For $2 < n < 7$ the situation is quite different: Here, the theoretical results that include the multiple capture contributions are in very good agreement with the experimental data, while those which ignore them yield considerably lower intensities. This demonstrates quite clearly that multiple capture processes play an important role in this collision system.

References

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[3] R. Ali *at al* 1994 *Phys. Rev. A* **49** 3586