Electron shakeoff subsequent to β^+ decay of $^{35}Ar^+$ and $^{19}Ne^+$ trapped ions

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Synopsis The electron shakeoff of ^{35}Cl and ^{19}F atoms resulting from the β^+ decay of $^{35}Ar^+$ and $^{19}Ne^+$ ions has been investigated using a Paul trap coupled to a recoil-ion spectrometer. The charge-state distributions of the recoiling daughter nuclei are compared to calculations based on the sudden approximation including Auger electron emission. The agreement is very good for ^{35}Cl but it slightly deteriorates for ^{19}F. This is attributed to the inaccuracy of the Independent Particle Model employed to compute the primary shakeoff probabilities, which is softened in the case of ^{35}Cl whose charge-state distribution is mainly dictated by Auger decay.

Precision measurements of the recoil-ion energy spectra in nuclear β decay constitute useful probes to test the Vector-Axial vector structure of the weak interaction. With this purpose, experiments using modern trapping techniques coupled to radioactive beams with high production rates have been developed during the last decade. They allow the detection of β particles and recoil ions in coincidence, providing a precise recoil-ion energy measurement with time of flight techniques.

The LPCTrap setup [1,2], installed at GANIL, provides the simultaneous measurement of both the charge-state and the energy of the recoil-ion. Fundamental atomic processes such as electron shakeoff resulting from the sudden change of the central potential can thus also be addressed through a measurement of the charge-state distribution of the recoiling daughter nuclei. With a single active electron, the β decay of $^{6}He^+$ ions provides a unique textbook case to test simple quantum mechanical calculations [1]. By contrast, heavier systems such as $^{19}Ne^+$ and $^{35}Ar^+$ ions involve more subtle shakeoff dynamics with several active electrons and subsequent relaxation processes such as Auger emission. The experimental ion-charge branching ratios obtained for ^{35}Cl were found in very good agreement with theoretical calculations [2]. The latter were based on an independent electron model (IPM), the use of the sudden approximation, and Hartree-Fock computations of the wave functions. Similar calculations applied to ^{19}F show significant deviations with the experimental data (see Fig. 1). We trace back the root of this discrepancy to the IPM approximation, which is known to overestimate the probabilities associated to multielectron ionization processes. This does not lead to noticeable deviations from experiments in the case of ^{35}Cl where single and multiple Auger decays play the major roles in the formation of highly charged states.

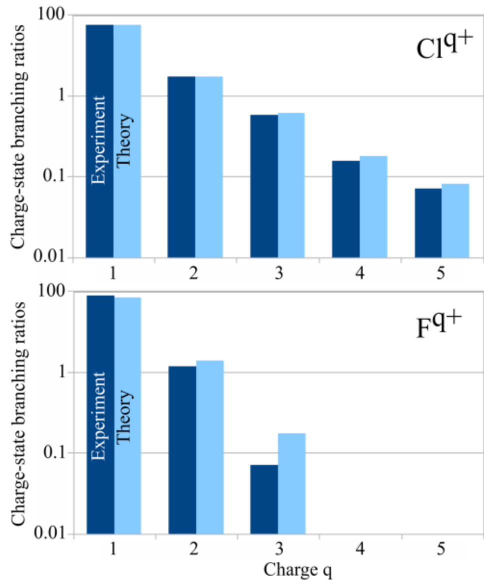

Figure 1. Experimental and theoretical ion-charge branching ratios (in %) obtained for ^{35}Cl and ^{19}F.

References

[1] C. Couratin et al., Phys. Rev. Lett. 108 (2012)
[2] C. Couratin et al., Phys. Rev. A 88 (2013)

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