Radiative electron capture: a tool for studying the charge changing processes during the Heavy ion-atom collisions

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Synopsis The present work comprises the study of K-REC process and its implication to explore the charge state evolution during the swift heavy ion-atom collisions. Measured K-REC energies have been used to calculate the mean electron binding energies and the mean charge states of the projectile ions. The measured mean charge states have been compared with various theoretical approaches and found to be in good agreement. Further, by the relative cross-section calculations, competitive behaviour between K-REC and characteristic transitions like K_α and K_β has also been observed.

It is well known that during the swift heavy ion-atom collisions, the interaction of ions with target atoms leads to the multiple vacancies in various shells of both the atomic systems. Subsequently, vacancies so created can be filled by radiative and non-radiative channels. A typical example is radiative electron capture (REC) process in which swift projectile ion captures loosely bound target electrons in its various vacant shells with the simultaneous emission of photons. Noteworthy that the REC peak structure explicitly depends on both the electron binding energy in the initial (i.e. target) and final (i.e. projectile) atomic systems as well as the projectile energy. Knowing the projectile energy and electron binding energy in the target, one can determine the mean binding energy in the projectile ion [1]. The main contribution to K-REC comes from the quasi-free target electron capture into the K-shell of bare and H-like ions. However, K-REC can also be evident in the case of multiply charged ions with the single or double K-vacancies created during the passage from the target [2]. In the present work, we have measured the K-REC x-ray spectra produced by the energetic projectile ions (^{56}Fe and ^{58}Ni) in the energy range of 96-156 MeV during the passage from thin carbon foils. As expected, the measured centroids of the K-REC peak are found varying linearly with the projectile energies. Further, using the K-REC X-ray centroid energy, we have approximated the mean binding energy of the projectile ions using the theoretical values of the binding energies corresponding to the multiply charged projectile ions [3]. Subsequently, from these values, we have obtained the equilibrium mean charge states of the projectile ions at different energies. The measured mean charge states of the projectile ions have been compared with the theoretical predictions of the Schiwietz semi-empirical formalism [4] and various version of the ETACHA code [5], as shown in the figure. It is found that the measured mean charge states compare well with the older version of ETACHA (i.e., v-2.3) [5] and Schiwietz formalism [4], whereas newer version of ETACAHA (i.e., v-3.4 and v-4) [5] show some discrepancies. Further, we have determined the ratio between K-REC and characteristic line intensities at various projectile energies and found that the ratio gradually decreases with the increasing projectile energy. It clearly illustrates the competitiveness between the two atomic processes during the ion-atom collisions. A similar trend is also observed in the absolute K x-ray production and K-REC cross sections. Detailed discussion on these aspects will be presented in the conference.

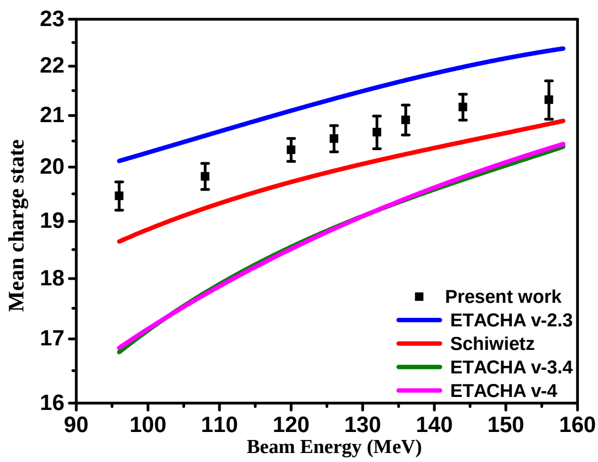

Figure 1. Comparison between experimental, ETACHA (v-2.3, v-3.4 & v-4) and Schiwietz mean charge state for the case of ^{58}Ni on ^{12}C for different beam energies.

References

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