Radiative de-excitation channel of slow highly charged ions transmitted through freestanding single layer graphene

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Synopsis X-ray emission spectra are recorded from slow (<1 a.u.) highly charged ions with and without K-shell vacancies in coincidence with charge exchange and energy loss measurements of these ions after they have passed a single layer of graphene.

Slow highly charged ions interacting with a solid surface undergo an ultrafast charge exchange combined with a rapid electronic de-excitation within less than 10 fs [1, 2]. These processes involve capture of some 10 electrons, emission of at least some 10 additional electrons from the surface and radiative as well as non-radiative de-excitation of the ion. To investigate the branching ratio of radiative vs. non-radiative de-excitation we measured x-ray emission of highly charged Ar ions with 2, 1 or no K-shell hole(s) when they are transmitted through a free-standing single layer of graphene. To discriminate x-ray emission from ions impacting on the sample holder or the graphene support grid structure we use a coincidence technique where ions are measured after transmission in a channeltron. Additionally the channeltron is mounted at the exit of an electrostatic analyzer, thus we have also access to the transmitted ion's energy and charge state.

Fig. 1 and 2 show x-ray emission spectra from Ar^{17+} and Ar^{18+}, respectively, due to their interaction with graphene.

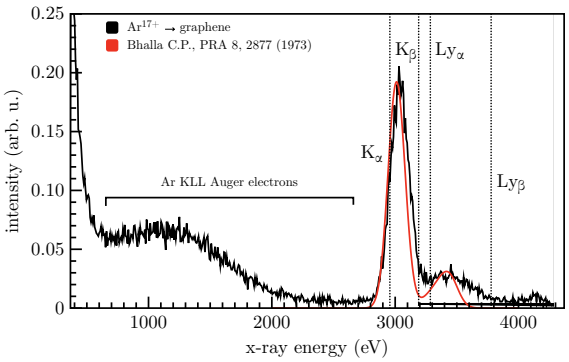

Figure 1. Ar^{17+} x-ray emission due to the ion interaction with graphene. The data is compared to calculations by Bhalla [3]

Peaks between the K_α- and the Ly_β-line are observed. These peak positions and their ratios can very well be reproduced by comparison to atomic structure code calculations by Bhalla and Mirakhmedov [3, 4] when their values and ratios are convoluted with a Gauss shaped detector function with a FWHM of 140 eV (energy resolution of the Bruker x-flash silicon drift detector).

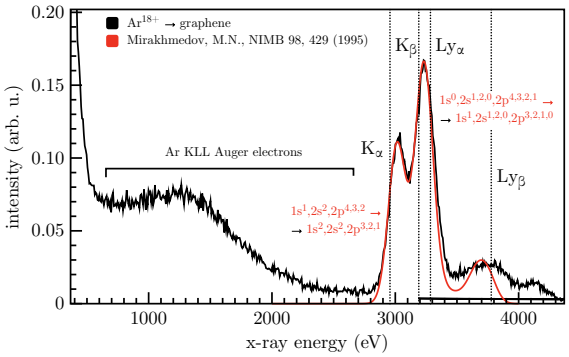

Figure 2. Ar^{18+} spectrum as in Fig. 1. The data is compared to calculations by Mirakhmedov [4]

From this comparison we see that the radiative K-shell emission occurs while the outer shells are not yet fully filled. Additionally, since we use a windowless silicon drift detector we are also sensitive to emitted electrons. From the spectrum we can directly identify Ar KLL Auger electrons (after passing through a thin dead layer in the detector surface) and estimate the branching ratio between radiative and non-radiative de-excitation for our experimental situation.

References

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