XES measurements of Terbium *L* x-ray transitions with the UNIFR Von Hamos spectrometer

Pierre Adatte

Master thesis in Atomic and X-Ray Physics

In this work, x-ray emission lines of terbium ($_{65}$Tb) and erbium ($_{68}$Er) were studied with the aim to characterize the *L* x-ray emission spectrum of terbium and a part of the one of erbium. This included the evaluation of the energy, the natural linewidth and the relative transition probability of each observed transition line from the L_3-, L_2- and L_1-subshells. A second goal, was to make a small compilation of the existing data to investigate the energy splitting of the L_3 $N_{4,5}$ ($L\beta_{14}$, $L\beta_{2,15}$) and L_2 N_4 ($L\gamma_9$, $L\gamma_1$) transition lines of lanthanides resulting from the *4d*-*4f* exchange interaction. Moreover, the correction calculations for the relative intensity probabilities were improved, mainly using the Python code, with the effect of reducing the number of required files and saving a lot of time for the user. The measurements were performed using the Von Hamos spectrometer of the University of Fribourg, which is a wavelength dispersive setup equipped with a curved crystal that makes its specificity and allows to perform high resolution measurements. The samples were exposed to a copper-anode x-ray tube, and the setup was calibrated using several *3d* transition metals as references. The line energies, the natural linewidths and the relative transition probabilities of terbium and erbium were extracted from the observed spectra. The experimental results were discussed in the context of existing data from common databases and published values. The 2021 FOWLER et al. publication was particularly and widely used to compare the terbium observations. Significant deviations have been noted for the terbium L_1 N_2 ($L\gamma_2$) and L_1 N_2 ($L\gamma_3$) transition lines and suggest a need of deeper investigations. The few erbium results showed important discrepancies for both the line energies and relative transition probabilities in comparison to reference values. Our results point to the need of expanding the measurements to more lines and to the reassessment of the reference data. Finally, we further substantiated and discussed two satellite lines the $L\beta_{2,15}$ and $L\gamma_1$ emission lines arising from the $N_{4,5}$ subshell. For rare-earth elements with partially filled *4f* shells, the intra-atomic exchange interactions between *4f* electrons and the core levels lead to low energy satellites and asymmetric emission line profiles due to multiplet structure. We attempted to characterize the L_3 $N_{4,5}$ ($L\beta_{2,15}$) and L_2 N_4 ($L\gamma_1$) splitting which is probably the most interesting point of this project and, in our opinion, has the most potential for further research.

Joanna Hoszowska