Universal empirical and theoretical fits to K- and L-shell x-ray production cross sections by protons

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The relevance of x-ray production cross sections (XRPCS) and the related ionization cross sections (ISC) in many research areas has been described at length and analyzed in detail [1]. X-ray emission cross sections by ion impact are a relevant input in many areas such as e.g., as for studies of track structure in DNA [2] or in water [3]. Particle Induced X-ray Emission (PIXE) strongly requires trustworthy databases for XRPCS and/or reliable predictions of inner-shell ionization theories as periodically evaluated in Monte Carlo Geant4 simulations [4,5].

In order to check if theories are accurate across the periodic table of elements and a large range of projectile energies, equally comprehensive databases are essential and a universal fit for them is desired. That fit should be in terms of a variable by which XRPCS are scaled with a minimum of adjustable parameters.

For each target element, the **compiled XRPCS** [1] follow a single curve when plotted versus the ratio of the proton velocity v_1 to the orbital velocity of $v_{2L}=Z_{2L}/n$ of the inner-shell electron. Furthermore, for all elements XRPCS peak at $\sigma_{LX}^{max}(Z_{2L})$ when $v_1 = v_{2L}$. Hence, with $v \equiv \log(v_1/v_{2L})$, a **universal fit** to all compiled data

$$\boldsymbol{\sigma_{LX}= \sigma_{LX}^{max}(Z_{2L})\cdot \exp[-(1+a_1 Z_{2L})v^2+a_2 v^7]} \qquad (1)$$

is made with just two adjustable parameters $a_1=0.00484$ and $a_2=0.005$. The predictions of the ECUSAR theory can be also fitted in a similar fashion.

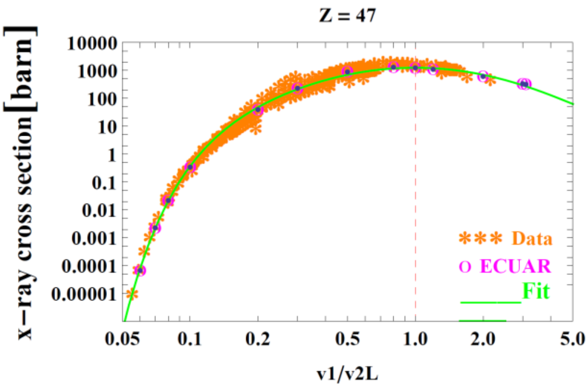

Figure 1. L-shell XRPCS for silver ionized by protons. Data compiled in [1] are compared with the ECUSAR theory [6], and the universal fit per Eq.(1).

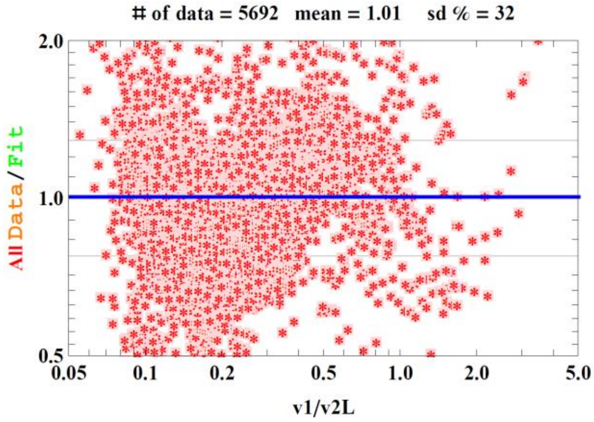

Figure 2. XRPCS for proton energies 26 eV≤E_1≤ 1 GeV and all elements with 24≤Z≤95 as compiled in [1] are in excellent agreement with the universal fit to these data as given in Eq.(1). Only 0.7% of Data/Fit ratios differs from 1.0 by more than a factor of 4; merely 3.4% differ by more than a factor of 2, while a Gaussian distribution would have to assume an experimentally unrealistic sd%=14 to be equally successful.

For this conference,

1) **a nearly three decades old tables of K-shell XRPCS [7,8] will be updated with a new compilation**,

2) **an universal empirical fit to this updated database will be made as shown here for the L shell**, and

3) **a similar fit to the predictions of the ECUSAR theory [6] will be presented**.

References

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