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## Erratum

## Errata and update to “Experimental cross sections for L-shell X-ray production and ionization by protons”

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## HIGHLIGHTS

- 2014 X-ray and ionization cross sections are corrected and updated.
- The update derives from older pre-2012 publications and includes post-2012 data.
- This update increases the database by 3.1%.
- The possible saturation in the cumulative number of data is elevated to 15 950 cross sections.

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## ABSTRACT

A compilation of experimental L-shell X-ray production and ionization cross sections induced by proton impact was published recently (Miranda and Lapicki, 2014), collecting 15 439 experimental cross sections. The database covers an energy range from 10 keV to 1 GeV, and targets from  $_{10}\text{Ne}$  to  $_{95}\text{Am}$ . A correction to several tabulated values that were in error, as well as an update including new data published after 2012 and older references not found previously are given in the present work. The updated data base increased the total number of experimental cross sections by 3.1% to 15 921. A new analysis of the total number of experimental points per year shows that the possible saturation in the cumulative total number of data is increased to  $15\,950 \pm 110$  points.

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## 1. Introduction

This errata and update is for a previous paper [1] where the relevance of X-ray production cross sections (XRPCS) and the related ionization cross sections (ICS) in many research areas has been described at length and analyzed in detail. The [1] paper enlarged the database compiled in earlier publications [2–4] by 94%.

## 2. Errata and update

The data compiled in [1] contain three different tables: Table 1 for XRPCS for the main lines ( $L_{\alpha}$ ,  $L_{\beta}$ ,  $L_{\gamma}$ ,  $L_1$ ,  $L_{\eta}$ ) and total XRPCS, Table 2 for ICS, and Table 3 lists XRPCS for sublines (such as  $L_{\alpha}$ ,  $L_{\beta 1}$ ,  $L_{\beta 2}$ ,  $L_{\gamma 1}$ ,  $L_{\gamma 2}$ ). In tables that had been submitted as additional material to the printed Table 1 in [1], all entries for Ta ( $Z_2 = 73$ ) are correct. However, in five rows for proton energies at 2.00, 2.05, 2.10, 2.10, and 2.16 MeV the printed Table 1 had misprinted references and cross sections. Hence as an errata in the present Table 1 these five rows are reprinted with ISH74 [5], BRA84 [6], LIU89 [7], BRA93 [8], GOU06 [9] and the cross sections from these references.

Some cross sections in Table 1 of [1] did not correspond to the values published in the original papers. As an errata to [1], they are corrected in the present Table 1 as follows:

- $L_{TOT}$  XRPCS from DYS73 [10] were corrected, as wrong atomic parameters were employed to reconstruct the data from experimental X-ray yields.
- Based on the tables by Hardt and Watson [2], 18 points from ABR74B [11] were assigned in [1] as  $L_{TOT}$  XRPCS to Pm ( $Z_2 = 61$ ). However, the original manuscript [11] shows that those data actually corresponded to Pr ( $Z_2 = 59$ ).
- Two  $L_{TOT}$  XRPCS at proton energies of 0.611 and 0.811 MeV for Ag ( $Z_2 = 47$ ) from CUZ81 [12] were not listed in [1].
- The  $L_{\beta}$  cross sections for Cs ( $Z_2 = 55$ ), Ba ( $Z_2 = 56$ ), and Gd ( $Z_2 = 64$ ) from AVA84 [13] mistakenly were given in [1] as the sum of  $L_{\beta}$  and  $L_{\beta 1}$  cross sections from that paper. Thus,  $L_{\beta}$  and  $L_{TOT}$  cross sections for those elements are corrected accordingly.
- One  $L_{TOT}$  XRPCS for Pb ( $Z_2 = 82$ ) at proton energy of 0.25 MeV in JES85 [14] was not listed in [1].
- One  $L_{TOT}$  XRPCS for Au ( $Z_2 = 79$ ) at proton energy of 0.5 MeV in STRO6 [15] was listed in [1] at 0.55 MeV and with a more accurate reading from a small log graph is now corrected to 1.20 b.

Our update includes data that were missed in [1]: FER72 [16], OLS72 [17], SIM77 [18], HAR84 [19], HAR86 [20], and TOT86 [21]. The present Table 1 lists XRPCS directly from FER72 [16] and HAR84 [19] as well as from HAR86 [20] whose ICSs were reconverted to XRPCSs with the atomic parameters cited therein.

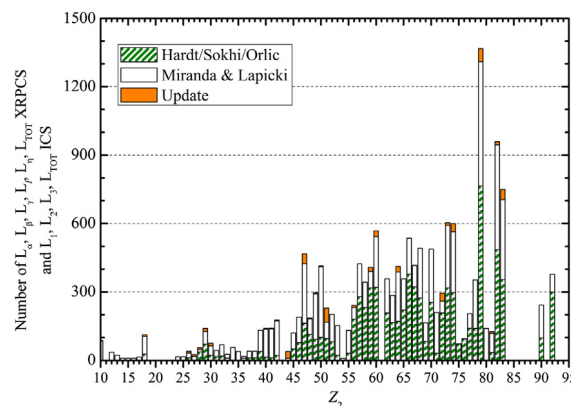


Fig. 1. Distribution of experimental L-shell ionization and X-ray production cross sections as a function of the target atomic number  $Z_2$  as previously compiled [1–4], updated in this work, and their sum. If  $\{L_1, L_2, L_3\}$  were reconverted to XRPCS as shown in Tables 1 and 2, these ICS are not counted in this work and the sum of the previous and this works. Numbers do include cross sections for L-subshell or L-X-ray line cross sections.

SIM77 [18] presented their total XRPCS for Pb ( $Z_2 = 82$ ) as X-ray yields per proton in a graphical comparison with Bernstein and Lewis [22] XRPCS, referenced in [1] as BER54. Using the BER54 data we normalized points displayed in a SIM77 graph to total XRPCS as shown in the present Table 1. OLS72 [17] measured L-shell X-ray spectrum of Sn ( $Z_2 = 50$ ) bombarded by 2 MeV protons. From the total M shell ICS and the ionization probability per M-shell electron in OLS72 [17], we have extracted their  $L_{TOT}$  ICS as listed in the present Table 2. This table also shows Ar ( $Z_2 = 18$ ) ICS from Auger measurements of TOT86 [21].

The search for data compiled in [1] terminated in December 2012. Excluding Miranda et al. [23] because their data are the same as those of MIR12B in [1], our update compiles in Table 1 XRPCS from six papers published after 2012: JOS13 [24], ZHO13 [25], BER14 [26], BAT14 [27], MOH14 [28], BER15 [29], and ZHO17 [30]. Except of MOH14, whose authors provided us with a table of their data as included in the present Table 1, all these works reported XRPCS in a tabular form. BER14 and BER15 published tables of  $L_{TOT}$  XRPCS produced by vacancies in the  $L_1$ ,  $L_2$  and  $L_3$  subshells; the authors sent us tables of their measured  $L_{\alpha}$ ,  $L_{\beta}$ ,  $L_{\gamma}$ ,  $L_1$  and  $L_{\eta}$  XRPCS as listed in Table 1 of this update. Fig. 1 displays a distribution of data versus target element with the new data added to the previous 2014 compilation [1]. Fig. 2 shows the cumulative number of experimental X-ray production and ionization experimental points (namely,  $L_{\alpha}$ ,  $L_{\beta}$ ,  $L_{\gamma}$ ,  $L_1$ ,  $L_{\eta}$ ,  $L_{TOT}$  XRPCS and  $L_1$ ,  $L_2$ ,  $L_3$ ,  $L_{1,T}$  ICS) from 1954 to 2017, as given in Refs. [1–4] and the present update. These numbers, up to April 2017, are fitted by a logistic curve that saturates at  $15\,950 \pm 110$  cross sections, instead of  $15\,500 \pm 120$  as shown in [1].

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