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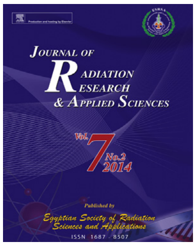

New procedure calculation of photon-induced Kβ/Kα intensity ratios for elements ^{16}S to ^{92}U

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ABSTRACT

In this paper, the measured Kβ/Kα intensity ratio values published in the literature from 1980 to 2011 have been reported. The weighted- and unweighted-mean values of the experimental data were fitted by the analytical function to deduce new semiempirical and empirical intensity ratios in the atomic range of $16 \le Z \le 92$. The semi-empirical intensity ratios were then deduced by fitting the experimental data normalized to their corresponding theoretical values and the experimental data were directly fitted to deduce the empirical ones. The results were compared with the other theoretical and experimental values reported in the literature.

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1. Introduction

The theoretical, experimental and analytical methods for the calculation of X-ray production cross sections, fluorescence yields, vacancy transfer probabilities and intensity ratios of different elements are very important because of the large number of their applications in various areas of physical chemistry and medical research. The investigation of the Kβ/Kα intensity ratio values have been performed many times using different experimental conditions by different workers before. The important theoretical calculations were made by Scofield (1974) using the Hartree-Slater theory. A deviations were observed (Ertuğral, Apaydin, Çevik, Ertuğral, & Kobya, 2007) between the theoretical and the experimental values and additionally between the different experimental data themselves. These situations motivated our research group to perform fittings with analytical functions based on the available experimental data to derive the semiempirical and empirical Kβ/Kα intensity ratios. This is the first paper presenting a summary of the experimental data of the Kβ/Kα intensity ratios which were taken directly from different sources (41 papers) published from 1980 to 2011. The semi-empirical and empirical Kβ/Kα intensity ratios of elements in the range $16 \le Z \le 92$ were deduced from the fittings of the weighted- and unweighted mean values using a polynomial fit. The semi-empirical intensity ratios were deduced by fitting the experimental data normalized to their corresponding theoretical values and on the other hand the experimental data were directly fitted to deduce the empirical ones. Finally, the obtained results were presented in a tabular form and were compared with theoretical and other experimental works.

2. Survey on the experimental works

Several authors have deduced Kβ/Kα intensity ratio values used different methods; these methods vary according to the changing experimental conditions such as ionization process, the target material, the detectors, ect. In 1980 Marques, Martins, and Ferreira (1980) measured the Kβ/Kα intensity ratios of 8 elements in the range $33 \le Z \le 57$ using a Si(Li) X-ray detector. Castini, Tartari, Baraldi, & Napoli (1985) measured the Kβ/Kα intensity ratios of ^{29}Cu, ^{42}Mo and ^{48}Cd using the characteristic radiation stimulated by the 59.54 keV gamma photons of a 500 mCi (18.5 GBq) ^{241}Am source. The Kβ/Kα intensity ratios for elements ^{22}Ti, ^{24}Cr and ^{28}Ni were measured by Bhuinya and Padhi (1992, 1993) using gamma rays of 59.54 keV from a 200 mCi ^{241}Am point source. Küçükönder, Şahin, Büyükkasap, and Kopya (1993) measured the intensity ratios for elements ^{24}Cr and ^{29}Cu and their various chemical compounds using a Ge(Li) detector. The Kβ/Kα intensity ratios of some vanadium compounds were measured by Chang et al. (1994) using 1.5 Ci ^{241}Am source. Dhal and Padhi (1994) measured the Kβ/Kα intensity ratios in the atomic region $25 \le Z \le 51$ ionized by 59.54 keV γ-rays from an ^{241}Am radioactive source. Padhi and Dhal (1995) measured the Kβ/Kα intensity ratios in the atomic region $26 \le Z \le 46$ using 59.54 keV γ-rays from a 200 mCi ^{241}Am point source. The Kβ/Kα intensity ratios for elements of ^{28}Ni and ^{29}Cu were measured using an excitation by 59.54 keV γ-rays from a 200 mCi ^{241}Am point source by Raj, Padhi, and Dhal (1998). Bé, Lépy, Plagnard, and Duchemin (1998) measured the Kβ/Kα X-ray intensity ratios in the atomic region $22 \le Z \le 29$ using a X-ray tube recorded with Si(Li) detector. Durak and Özdemir (1998) measured the Kβ/Kα intensity ratios in some elements from ^{60}Nd to ^{82}Pb ionized by 123.6 keV photons. The Kβ/Kα intensity ratios for ^{22}Ti, ^{23}V, ^{24}Cr and ^{27}Co were measured by Raj, Padhi, Basa, Polasik, and Pawłowski (1999) using an excitation by 59.54 keV γ-rays from a 200 mCi ^{241}Am point source. The same research group (Raj, Padhi, & Polasik, 2000; Raj et al., 2002) reported the Kβ/Kα intensity ratios in the atomic region $22 \le Z \le 29$. Söğüt, Seven, Baydaş, Büyükkasap, and Küçükönder (2001) measured the Kβ/Kα intensity ratios in the atomic region $42 \le Z \le 58$ by 59.5 keV γ-rays from a filtered ^{241}Am radioactive source. Ertugrul et al. (2001) determined the Kα and Kβ X-ray polarization degree and polarization effect on the Kβ/Kα intensity ratios of several elements of ^{57}La, ^{58}Ce, ^{59}Pr, ^{60}Nd, ^{62}Sm, ^{63}Eu, ^{64}Gd, ^{65}Tb, ^{66}Dy, ^{67}Ho, ^{68}Er and ^{69}Tm using 100 mCi ^{241}Am filtered radioisotope point source and measured the Kβ/Kα intensity ratios for elements in the range $22 \le Z \le 69$ using a Si(Li) detector (160 eV FWHM at 5.9 keV) Ertugrul, Sögüt, Şimşek, Büyükkasap (2001). Sogut, Büyükkasap, and Erdoğan (2002) was measured the Kβ/Kα X-ray intensity ratio for elements in the range $22 \le Z \le 30$ using Si(Li) solid state detector with high resolution by 5.9 keV γ-rays from a filtered ^{241}Am source. Ertugrul (2002) determined the Kβ/Kα X-ray intensity ratios of some elements in the atomic range $30 \le Z \le 40$ using 59.5 keV γ-rays. Pawłowski, Polasik, Raj, Padhi, and Basa (2002) measured the Kβ/Kα X-ray intensity ratios for elements of ^{22}Ti, ^{24}Cr, ^{26}Fe and ^{27}Co excited by 59.54 keV γ-rays from 7400 MBq (200 mCi) ^{241}Am point source. Ertugrul, Karabulut, and Budak (2002) measured the K-shell absorption jump factor and the Kβ/Kα X-ray intensity ratios of some elements in the atomic range $40 \le Z \le 60$ using Si(Li) detector (FWHM = 160 eV at 5.96 keV). Şahin, Demir, and Budak (2005) studied Kβ/Kα X-ray intensity ratios for six elements in the range $16 \le Z \le 23$ at 5.96 keV. Chemical effect on the Kβ/Kα X-ray intensity ratios of ^{25}Mn, ^{28}Ni and ^{29}Cu complexes of a new Schiff-base with salen N_2H_2 type were investigated by Çevik, Değirmencioğlu, Ertuğral, Apaydin, and Baltaş (2005) using 59.543 keV γ-rays from an ^{241}Am annular radioactive source. The Kβ/Kα X-ray intensity ratios for 17 elements from ^{25}Mn to ^{42}Mo were measured by Öz (2006) using 59.5 keV γ-rays from a ^{241}Am point source. Bennal and Badiger (2006) determined the Kβ/Kα intensity ratios by adopting 2π geometrical configuration for the elements ^{73}Ta, ^{79}Au and ^{89}Pb. Han, Şahin, Demir, and Şahin (2007) measured the K X-ray fluorescence cross sections, fluorescence yields and intensity ratios in the atomic region $22 \le Z \le 68$ excited by 59.54 keV γ-rays from ^{241}Am filtered point source. Demir and Şahin (2007a, 2007b) measured the Kβ/Kα X-ray intensity ratios for ^{60}Nd, ^{63}Eu, ^{64}Gd, ^{66}Dy and ^{67}Ho using the 59.5 keV photons in an external magnetic field. The experimental values of Kβ/Kα were obtained for the elements ^{24}Cr, ^{26}Fe, ^{27}Co, ^{29}Cu, ^{30}Zn, ^{31}Ga, ^{34}Se, ^{39}Y, ^{42}Mo, ^{48}Cd, ^{49}In, ^{50}Sn, ^{52}Te, ^{56}Ba, ^{73}Ta, ^{74}W and ^{83}Bi by Cevik et al. (Cevik, Kaya, Ertugral, Baltas, & Karabidak, 2007) using 59.5 keV photons emitted by a 50 mCi ^{241}Am radioactive source. Kalayci, Aydinuraz,

Table 1 – Summary of the experimental Kβ/Kα intensity ratios, *Unweighted average value* ($\overline{K\beta/K\alpha}$), *Weighted average value* ($\overline{K\beta/K\alpha}_W$), *Unweighted standard deviation* (USD(Kβ/Kα)), *Weighted standard deviation* (WSD (Kβ/Kα)) and *Unweighted Standard errors* (USE (Kβ/Kα)).

Z	Kβ/Kα(exp)	References	$\overline{K\beta/K\alpha}$	$\overline{K\beta/K\alpha}_W$	USD(Kβ/Kα)	WSD (Kβ/Kα)	USE (Kβ/Kα)
Z = 16, S	0.0525 ± 0.0021	(Şahin et al., 2005)	0.0558	0.0539	0.0047	0.0033	0.0033
	0.0591 ± 0.0040	(Ertuğral et al., 2007)					
Z = 17, Cl	0.0678 ± 0.0027	(Şahin et al., 2005)	0.0688	0.0683	0.0014	0.0010	0.0010
	0.0698 ± 0.0050	(Ertuğral et al., 2007)					
Z = 19, K	0.0951 ± 0.0038	(Şahin et al., 2005)	0.1039	0.0983	0.0124	0.0088	0.0088
	0.1126 ± 0.0080	(Ertuğral et al., 2007)					
Z = 20, Ca	0.1050 ± 0.0042	(Şahin et al., 2005)	0.1139	0.1109	0.0126	0.0089	0.0089
	0.1228 ± 0.0060	(Ertuğral et al., 2007)					
Z = 21, Sc	0.1268 ± 0.0050	(Ertuğral et al., 2007)	0.1268	0.1268	–	undefined	–
Z = 22, Ti	0.1282 ± 0.0014	(Bhuinya and Padhi, 1992)	0.1252	0.1269	0.0089	0.0029	0.0027
	0.1289 ± 0.0014	(Bhuinya and Padhi, 1993)					
	0.1359 ± 0.0017	(Bé et al., 1998)					
	0.1265 ± 0.0006	(Raj et al., 1999)					
	0.1210 ± 0.0100	(Ertuğrul, Sögüt, et al., 2001)					
	0.1265 ± 0.0006	(Raj et al., 2002)					
	0.1364 ± 0.0134	(Sogut et al., 2002)					
	0.1265 ± 0.0006	(Pawłowski et al., 2002)					
	0.1089 ± 0.0043	(Şahin et al., 2005)					
	0.1100 ± 0.0090	(Han et al., 2007)					
	0.1282 ± 0.0080	(Ertuğral et al., 2007)					
Z = 23, V	0.1479 ± 0.0003	(Chang et al., 1994)	0.1284	0.1396	0.0100	0.0158	0.0032
	0.1363 ± 0.0017	(Bé et al., 1998)					
	0.1312 ± 0.0008	(Raj et al., 1999)					
	0.1312 ± 0.0008	(Raj et al., 2002)					
	0.1316 ± 0.0111	(Sogut et al., 2002)					
	0.1244 ± 0.0050	(Şahin et al., 2005)					
	0.1130 ± 0.0090	(Han et al., 2007)					
	0.1294 ± 0.0060	(Ertuğral et al., 2007)					
	0.1166 ± 0.0009	(Yalçin, 2007)					
	0.1227 ± 0.0007	(Yalçin, 2007)					
Z = 24, Cr	0.1338 ± 0.0009	(Bhuinya and Padhi, 1993)	0.1294	0.1307	0.0082	0.0055	0.0024
	0.1124 ± 0.0013	(Küçükönder et al. 1993)					
	0.1394 ± 0.0017	(Bé et al., 1998)					
	0.1314 ± 0.0008	(Raj et al., 1999)					
	0.1314 ± 0.0008	(Raj et al., 2000)					
	0.1280 ± 0.0100	(Ertuğrul, Sögüt, et al., 2001)					
	0.1314 ± 0.0008	(Raj et al., 2002)					
	0.1341 ± 0.0130	(Sogut et al., 2002)					
	0.1314 ± 0.0008	(Pawłowski et al., 2002)					
	0.1130 ± 0.0090	(Han et al., 2007)					
	0.1320 ± 0.0050	(Cevik et al., 2007)					
	0.1342 ± 0.0050	(Ertuğral et al., 2007)					
Z = 25, Mn	0.1383 ± 0.0017	(Bé et al., 1998)	0.1283	0.1284	0.0105	0.0075	0.0032
	0.1344 ± 0.0009	(Raj et al., 2000)					
	0.1310 ± 0.0130	(Ertuğrul et al., 2001b)					
	0.1344 ± 0.0009	(Raj et al., 2002)					
	0.1235 ± 0.0104	(Sogut et al., 2002)					
	0.1270 ± 0.0060	(Çevik et al., 2005)					
	0.1320 ± 0.0110	(Öz,2006)					
	0.1060 ± 0.0080	(Han et al., 2007)					
	0.1440 ± 0.0040	(Ertuğral et al., 2007)					
	0.1188 ± 0.0011	(Yalçin, 2007)					
	0.1214 ± 0.0008	(Yalçin, 2007)					
Z = 26, Fe	0.1290 ± 0.0005	(Padhi and Dhal, 1995)	0.1311	0.1302	0.0047	0.0020	0.0015
	0.1372 ± 0.0017	(Bé et al., 1998)					
	0.1330 ± 0.0110	(Ertuğrul, Sögüt, et al., 2001)					
	0.1307 ± 0.0007	(Raj et al., 2002)					
	0.1287 ± 0.0110	(Sogut et al., 2002)					
	0.1307 ± 0.0007	(Pawłowski et al., 2002)					
	0.1340 ± 0.0120	(Öz,2006)					
	0.1200 ± 0.0100	(Han et al., 2007)					
	0.1350 ± 0.0070	(Cevik et al., 2007)					
	0.1324 ± 0.0050	(Ertuğral et al., 2007)					

Table 1 – (*continued*)

Z	Kβ/Kα(exp)	References	$\overline{K\beta/K\alpha}$	$\overline{K\beta/K\alpha}_W$	USD(Kβ/Kα)	WSD (Kβ/Kα)	USE (Kβ/Kα)
Z = 27, Co	0.1285 ± 0.0006	(Padhi and Dhal, 1995)	0.1328	0.1322	0.0053	0.0028	0.0012
	0.1379 ± 0.0017	(Bé et al., 1998)					
	0.1335 ± 0.0008	(Raj et al., 1999)					
	0.1335 ± 0.0008	(Raj et al., 2000)					
	0.1330 ± 0.0100	(Ertuğrul, Sögüt, et al., 2001)					
	0.1335 ± 0.0008	(Raj et al., 2002)					
	0.1387 ± 0.0140	(Sogut et al., 2002)					
	0.1335 ± 0.0008	(Pawłowski et al., 2002)					
	0.1370 ± 0.0110	(Öz,2006)					
	0.1370 ± 0.0080	(Cevik et al., 2007)					
	0.1390 ± 0.0070	(Ertuğral et al., 2007)					
	0.1390 ± 0.0030	(Porikli and kurucu, 2008)					
	0.1310 ± 0.0050	(Porikli and kurucu, 2008)					
	0.1240 ± 0.0050	(Porikli and kurucu, 2008)					
	0.1313 ± 0.0087	(Kup Aylikci et al., 2009)					
	0.1342 ± 0.0063	(Han and Demir, 2010)					
	0.1230 ± 0.0062	(Kup Aylikci et al., 2010)					
	0.1230 ± 0.0062	(Kup Aylikci et al., 2011)					
Z = 28, Ni	0.1356 ± 0.0006	(Bhuinya and Padhi, 1992)	0.1367	0.1358	0.0059	0.0018	0.0014
	0.1368 ± 0.0006	(Bhuinya and Padhi, 1993)					
	0.1371 ± 0.0006	(Bhuinya and Padhi, 1993)					
	0.1336 ± 0.0005	(Padhi and Dhal, 1995)					
	0.1363 ± 0.0006	(Raj et al., 1998)					
	0.1377 ± 0.0017	(Bé et al., 1998)					
	0.1350 ± 0.0120	(Ertuğrul, Sögüt, et al., 2001)					
	0.1346 ± 0.0012	(Raj et al., 2002)					
	0.1466 ± 0.0124	(Sogut et al., 2002)					
	0.1410 ± 0.0120	(Çevik et al., 2005)					
	0.1380 ± 0.0110	(Öz,2006)					
	0.1190 ± 0.0090	(Han et al., 2007)					
	0.1378 ± 0.0010	(Kalayci et al., 2007)					
	0.1330 ± 0.0030	(Ertuğral et al., 2007)					
	0.1450 ± 0.0040	(Porikli and kurucu, 2008)					
	0.1410 ± 0.0050	(Porikli and kurucu, 2008)					
	0.1350 ± 0.0050	(Porikli and kurucu, 2008)					
Z = 29, Cu	0.1382 ± 0.0016	(Casnati et al., 1985)	0.1339	0.1345	0.0054	0.0030	0.0014
	0.1211 ± 0.0019	(Küçükönder et al. 1993)					
	0.1335 ± 0.0006	(Padhi and Dhal, 1995)					
	0.1360 ± 0.0006	(Raj et al., 1998)					
	0.1358 ± 0.0017	(Bé et al., 1998)					
	0.1340 ± 0.0130	(Ertuğrul, Sögüt, et al., 2001)					
	0.1343 ± 0.0012	(Raj et al., 2002)					
	0.1374 ± 0.0113	(Sogut et al., 2002)					
	0.1370 ± 0.0110	(Çevik et al., 2005)					
	0.1390 ± 0.0130	(Öz,2006)					
	0.1220 ± 0.0100	(Han et al., 2007)					
	0.1360 ± 0.0050	(Cevik et al., 2007)					
	0.1359 ± 0.0030	(Ertuğral et al., 2007)					
	0.1314 ± 0.0087	(Kup Aylikci et al., 2009)					
	0.1370 ± 0.0052	(Han and Demir, 2010)					
Z = 30, Zn	0.1360 ± 0.0100	(Ertuğrul, Sögüt, et al., 2001)	0.1318	0.1245	0.0114	0.0087	0.0034
	0.1254 ± 0.0102	(Sogut et al., 2002)					
	0.1580 ± 0.0050	(Ertugrul, 2002)					
	0.1410 ± 0.0100	(Öz,2006)					
	0.1260 ± 0.0100	(Han et al., 2007)					
	0.1360 ± 0.0050	(Cevik et al., 2007)					
	0.1379 ± 0.0050	(Ertuğral et al., 2007)					
	0.1225 ± 0.0007	(Yalçin, 2007)					
	0.1267 ± 0.0011	(Yalçin, 2007)					
	0.1200 ± 0.0061	(Kup Aylikci et al., 2010)					
	0.1200 ± 0.0061	(Kup Aylikci et al., 2011)					
Z = 31, Ga	0.1430 ± 0.0110	(Öz,2006)	0.1430	0.1430	0.0000	0.0000	0.0000
	0.1430 ± 0.0060	(Cevik et al., 2007)					

(*continued on next page*)

Table 1 – (continued)

Z	Kβ/Kα(exp)	References	$\overline{K\beta/K\alpha}$	$\overline{K\beta/K\alpha}_W$	USD(Kβ/Kα)	WSD (Kβ/Kα)	USE (Kβ/Kα)
Z = 32, Ge	0.1520 ± 0.0120	(Öz,2006)	0.1415	0.1396	0.0148	0.0105	0.0105
	0.1310 ± 0.0100	(Han et al., 2007)					
Z = 33, As	0.1543 ± 0.0250	(Marques et al., 1980)	0.1522	0.1532	0.0090	0.0074	0.0037
	0.1520 ± 0.0110	(Ertuğrul, Sögüt, et al., 2001)					
	0.1630 ± 0.0070	(Ertugrul, 2002)					
	0.1570 ± 0.0110	(Öz,2006)					
	0.1360 ± 0.0110	(Han et al., 2007)					
	0.1511 ± 0.0050	(Ertuğral et al., 2007)					
Z = 34, Se	0.1570 ± 0.0120	(Ertuğrul, Sögüt, et al., 2001)	0.1622	0.1630	0.0037	0.0031	0.0016
	0.1640 ± 0.0100	(Ertugrul, 2002)					
	0.1620 ± 0.0110	(Öz,2006)					
	0.1670 ± 0.0060	(Cevik et al., 2007)					
	0.1612 ± 0.0050	(Ertuğral et al., 2007)					
Z = 35, Br	0.1680 ± 0.0100	(Ertuğrul, Sögüt, et al., 2001)	0.1621	0.1646	0.0127	0.0093	0.0064
	0.1690 ± 0.0100	(Öz,2006)					
	0.1430 ± 0.0110	(Han et al., 2007)					
	0.1682 ± 0.0060	(Ertuğral et al., 2007)					
Z = 37, Rb	0.1766 ± 0.0018	(Marques et al., 1980)	0.1719	0.1762	0.0078	0.0052	0.0032
	0.1710 ± 0.0150	(Ertuğrul, Sögüt, et al., 2001)					
	0.1700 ± 0.0090	(Ertugrul, 2002)					
	0.1750 ± 0.0110	(Öz,2006)					
	0.1580 ± 0.0130	(Han et al., 2007)					
	0.1806 ± 0.0070	(Ertuğral et al., 2007)					
Z = 38, Sr	0.1828 ± 0.0018	(Marques et al., 1980)	0.1780	0.1811	0.0090	0.0064	0.0040
	0.1810 ± 0.0160	(Ertuğrul, Sögüt, et al., 2001)					
	0.1620 ± 0.0060	(Ertugrul, 2002)					
	0.1830 ± 0.0100	(Öz,2006)					
	0.1812 ± 0.0090	(Ertuğral et al., 2007)					
Z = 39, Y	0.1740 ± 0.0090	(Ertugrul, 2002)	0.1815	0.1840	0.0095	0.0081	0.0043
	0.1880 ± 0.0100	(Öz,2006)					
	0.1690 ± 0.0140	(Han et al., 2007)					
	0.1910 ± 0.0070	(Cevik et al., 2007)					
	0.1856 ± 0.0090	(Ertuğral et al., 2007)					
Z = 40, Zr	0.1910 ± 0.0160	(Ertuğrul, Sögüt, et al., 2001)	0.1843	0.1857	0.0089	0.0060	0.0036
	0.1850 ± 0.0060	(Ertugrul, 2002)					
	0.1760 ± 0.0180	(Ertugrul et al.,, 2002)					
	0.1930 ± 0.0140	(Öz,2006)					
	0.1710 ± 0.0140	(Han et al., 2007)					
	0.1898 ± 0.0080	(Ertuğral et al., 2007)					
Z = 41, Nb	0.1960 ± 0.0120	(Öz,2006)	0.1911	0.1945	0.0115	0.0087	0.0066
	0.1780 ± 0.0140	(Han et al., 2007)					
	0.1993 ± 0.0080	(Ertuğral et al., 2007)					
Z = 42, Mo	0.1974 ± 0.0015	(Casnati et al., 1985)	0.1938	0.2036	0.0080	0.0104	0.0025
	0.2048 ± 0.0005	(Padhi and Dhal, 1995)					
	0.1898 ± 0.0150	(Söğüt et al., 2001)					
	0.1930 ± 0.0140	(Ertuğrul, Sögüt, et al., 2001)					
	0.1820 ± 0.0090	(Ertugrul et al.,, 2002)					
	0.2020 ± 0.0100	(Öz,2006)					
	0.1970 ± 0.0060	(Cevik et al., 2007)					
	0.2016 ± 0.0040	(Ertuğral et al., 2007)					
	0.1850 ± 0.0050	(Bennal and Badiger, 2007)					
	0.1850 ± 0.0050	(Bennal et al., 2010)					
Z = 43, Tc	0.1776 ± 0.0008	(Yalçin, 2007)	0.1815	0.1815	0.0054	0.0038	0.0038
	0.1853 ± 0.0008	(Yalçin, 2007)					
Z = 44, Ru	0.2126 ± 0.0005	(Padhi and Dhal, 1995)	0.1964	0.2066	0.0177	0.0162	0.0088
	0.1980 ± 0.0160	(Ertuğrul, Sögüt, et al., 2001)					
	0.1714 ± 0.0013	(Yalçin, 2007)					
	0.2034 ± 0.0010	(Yalçin, 2007)					
Z = 45, Rh	0.2033 ± 0.0020	(Marques et al., 1980)	0.2077	0.2075	0.0044	0.0011	0.0025
	0.2078 ± 0.0005	(Padhi and Dhal, 1995)					
	0.2120 ± 0.0170	(Ertuğrul, Sögüt, et al., 2001)					
Z = 46, Pd	0.2061 ± 0.0016	(Marques et al., 1980)	0.2059	0.2118	0.0059	0.0062	0.0030
	0.2124 ± 0.0005	(Padhi and Dhal, 1995)					
	0.2070 ± 0.0140	(Ertuğrul, Sögüt, et al., 2001)					
	0.1980 ± 0.0090	(Ertugrul et al.,, 2002)					

Table 1 – (*continued*)

Z	Kβ/Kα(exp)	References	$\overline{K\beta/K\alpha}$	$\overline{K\beta/K\alpha}_W$	USD(Kβ/Kα)	WSD (Kβ/Kα)	USE (Kβ/Kα)
Z = 47, Ag	0.2105 ± 0.0021	(Marques et al., 1980)	0.2053	0.2011	0.0074	0.0054	0.0026
	0.2009 ± 0.0003	(Dhal and Padhi, 1994)					
	0.2170 ± 0.0150	(Ertuğrul, Sögüt, et al., 2001)					
	0.1980 ± 0.0100	(Ertugrul et al.,, 2002)					
	0.2096 ± 0.0040	(Ertuğral et al., 2007)					
	0.1980 ± 0.0030	(Bennal and Badiger, 2007)					
	0.2101 ± 0.0139	(Kup Aylikci et al., 2009)					
	0.1980 ± 0.0030	(Bennal et al., 2010)					
Z = 48, Cd	0.2141 ± 0.0012	(Casnati et al., 1985)	0.2081	0.2112	0.0067	0.0052	0.0020
	0.2141 ± 0.0009	(Dhal and Padhi, 1994)					
	0.2127 ± 0.0130	(Söğüt et al., 2001)					
	0.2170 ± 0.0150	(Ertuğrul, Sögüt, et al., 2001)					
	0.2000 ± 0.0160	(Han et al., 2007)					
	0.2120 ± 0.0070	(Cevik et al., 2007)					
	0.2035 ± 0.0060	(Ertuğral et al., 2007)					
	0.2068 ± 0.0011	(Yalçin, 2007)					
	0.2106 ± 0.0022	(Yalçin, 2007)					
	0.1990 ± 0.0040	(Bennal and Badiger, 2007)					
	0.1990 ± 0.0040	(Bennal et al., 2010)					
Z = 49, In	0.2147 ± 0.0021	(Marques et al., 1980)	0.2109	0.2102	0.0070	0.0051	0.0027
	0.2200 ± 0.0180	(Ertuğrul, Sögüt, et al., 2001)					
	0.2030 ± 0.0160	(Han et al., 2007)					
	0.2190 ± 0.0080	(Cevik et al., 2007)					
	0.2098 ± 0.0090	(Ertuğral et al., 2007)					
	0.2050 ± 0.0030	(Bennal and Badiger, 2007)					
	0.2050 ± 0.0030	(Bennal et al., 2010)					
Z = 50, Sn	0.2183 ± 0.0006	(Dhal and Padhi, 1994)	0.2129	0.2175	0.0090	0.0054	0.0034
	0.2260 ± 0.0200	(Ertuğrul, Sögüt, et al., 2001)					
	0.2060 ± 0.0170	(Han et al., 2007)					
	0.2210 ± 0.0090	(Cevik et al., 2007)					
	0.2086 ± 0.0110	(Ertuğral et al., 2007)					
	0.2080 ± 0.0030	(Bennal and Badiger, 2007)					
	0.2080 ± 0.0030	(Bennal et al., 2010)					
Z = 51, Sb	0.2280 ± 0.0160	(Ertuğrul, Sögüt, et al., 2001)	0.2216	0.2233	0.0085	0.0049	0.0049
	0.2120 ± 0.0120	(Ertugrul et al.,, 2002)					
	0.2248 ± 0.0050	(Ertuğral et al., 2007)					
Z = 52, Te	0.2300 ± 0.0180	(Ertuğrul, Sögüt, et al., 2001)	0.2251	0.2231	0.0054	0.0044	0.0031
	0.2260 ± 0.0090	(Cevik et al., 2007)					
	0.2194 ± 0.0080	(Ertuğral et al., 2007)					
Z = 53, I	0.2340 ± 0.0160	(Ertuğrul, Sögüt, et al., 2001)	0.2276	0.2237	0.0091	0.0065	0.0065
	0.2211 ± 0.0080	(Ertuğral et al., 2007)					
Z = 54, Xe	0.2103 ± 0.0009	(Yalçin, 2007)	0.2234	0.2249	0.0185	0.0131	0.0131
	0.2365 ± 0.0008	(Yalçin, 2007)					
Z = 55, Cs	0.2340 ± 0.0180	(Ertuğrul, Sögüt, et al., 2001)	0.2220	0.2171	0.0128	0.0108	0.0057
	0.2165 ± 0.0007	(Yalçin, 2007)					
	0.2287 ± 0.0012	(Yalçin, 2007)					
	0.2021 ± 0.0010	(Yalçin, 2007)					
	0.2287 ± 0.0012	(Yalçin, 2007)					
Z = 56, Ba	0.2350 ± 0.0170	(Ertuğrul, Sögüt, et al., 2001)	0.2323	0.2294	0.0102	0.0110	0.0036
	0.2270 ± 0.0180	(Han et al., 2007)					
	0.2380 ± 0.0100	(Cevik et al., 2007)					
	0.2472 ± 0.0050	(Ertuğral et al., 2007)					
	0.2118 ± 0.0013	(Yalçin, 2007)					
	0.2355 ± 0.0008	(Yalçin, 2007)					
	0.2307 ± 0.0058	(Timmaraju and Premachand, 2009)					
	0.2331 ± 0.0058	(Timmaraju and Premachand, 2009)					
Z = 57, La	0.2414 ± 0.0036	(Marques et al., 1980)	0.2452	0.2432	0.0061	0.0043	0.0030
	0.2420 ± 0.0020	(Ertugrul, Şimşek, et al., 2001)					
	0.2430 ± 0.0210	(Ertuğrul, Sögüt, et al., 2001)					
	0.2542 ± 0.0050	(Ertuğral et al., 2007)					
Z = 58, Ce	0.2450 ± 0.0020	(Ertugrul, Şimşek, et al., 2001)	0.2444	0.2452	0.0021	0.0010	0.0009
	0.2440 ± 0.0180	(Ertuğrul, Sögüt, et al., 2001)					
	0.2410 ± 0.0130	(Ertugrul et al.,, 2002)					

(*continued on next page*)

Table 1 – (*continued*)

Z	Kβ/Kα(exp)	References	$\overline{K\beta/K\alpha}$	$\overline{K\beta/K\alpha}_W$	USD(Kβ/Kα)	WSD (Kβ/Kα)	USE (Kβ/Kα)
	0.2460 ± 0.0050	(Ertuğral et al., 2007)					
	0.2460 ± 0.0050	(Ertuğral , 2007)					
Z = 59, Pr	0.2550 ± 0.0020	(Ertugrul, Şimşek, et al., 2001)	0.2443	0.2508	0.0084	0.0098	0.0042
	0.2470 ± 0.0190	(Ertuğrul, Sögüt, et al., 2001)					
	0.2376 ± 0.0050	(Ertuğral et al., 2007)					
	0.2376 ± 0.0050	(Ertuğral , 2007)					
	0.2350 ± 0.0200	(Durak and Özdemir, 1998)					
Z = 60, Nd	0.2470 ± 0.0020	(Ertugrul, Şimşek, et al., 2001)	0.2449	0.2450	0.0048	0.0031	0.0014
	0.2480 ± 0.0180	(Ertuğrul, Sögüt, et al., 2001)					
	0.2470 ± 0.0140	(Ertugrul et al.,, 2002)					
	0.2420 ± 0.0060	(Demir and Şahin, 2007a)					
	0.2490 ± 0.0150	(Demir and Şahin, 2007a)					
	0.2490 ± 0.0150	(Demir and Şahin, 2007a)					
	0.2418 ± 0.0060	(Demir and Şahin, 2007b)					
	0.2495 ± 0.0150	(Demir and Şahin, 2007b)					
	0.2495 ± 0.0150	(Demir and Şahin, 2007b)					
	0.2402 ± 0.0050	(Ertuğral et al., 2007)					
	0.2402 ± 0.0050	(Ertuğral , 2007)					
	0.2400 ± 0.0220	(Durak and Özdemir, 1998)					
Z = 62, Sm	0.2520 ± 0.0020	(Ertugrul, Şimşek, et al., 2001)	0.2454	0.2510	0.0054	0.0062	0.0022
	0.2510 ± 0.0190	(Ertuğrul, Sögüt, et al., 2001)					
	0.2390 ± 0.0190	(Han et al., 2007)					
	0.2451 ± 0.0080	(Ertuğral et al., 2007)					
	0.2451 ± 0.0080	(Ertuğral , 2007)					
	0.2420 ± 0.0180	(Durak and Özdemir, 1998)					
Z = 63, Eu	0.2540 ± 0.0030	(Ertugrul, Şimşek, et al., 2001)	0.2453	0.2463	0.0073	0.0072	0.0022
	0.2540 ± 0.0200	(Ertuğrul, Sögüt, et al., 2001)					
	0.2390 ± 0.0150	(Demir and Şahin, 2007a)					
	0.2400 ± 0.0030	(Demir and Şahin, 2007a)					
	0.2400 ± 0.0030	(Demir and Şahin, 2007a)					
	0.2388 ± 0.0150	(Demir and Şahin, 2007b)					
	0.2402 ± 0.0030	(Demir and Şahin, 2007b)					
	0.2403 ± 0.0030	(Demir and Şahin, 2007b)					
	0.2549 ± 0.0030	(Ertuğral et al., 2007)					
	0.2549 ± 0.0030	(Ertuğral , 2007)					
	0.2440 ± 0.0210	(Durak and Özdemir, 1998)					
Z = 64, Gd	0.2570 ± 0.0030	(Ertugrul, Şimşek, et al., 2001)	0.2510	0.2534	0.0065	0.0065	0.0019
	0.2550 ± 0.0200	(Ertuğrul, Sögüt, et al., 2001)					
	0.2440 ± 0.0200	(Han et al., 2007)					
	0.2470 ± 0.0050	(Demir and Şahin, 2007a)					
	0.2480 ± 0.0060	(Demir and Şahin, 2007a)					
	0.2480 ± 0.0060	(Demir and Şahin, 2007a)					
	0.2473 ± 0.0050	(Demir and Şahin, 2007b)					
	0.2487 ± 0.0060	(Demir and Şahin, 2007b)					
	0.2481 ± 0.0060	(Demir and Şahin, 2007b)					
	0.2622 ± 0.0050	(Ertuğral et al., 2007)					
	0.2622 ± 0.0050	(Ertuğral , 2007)					
Z = 65, Tb	0.2590 ± 0.0030	(Ertugrul, Şimşek, et al., 2001)	0.2562	0.2578	0.0041	0.0032	0.0024
	0.2580 ± 0.0200	(Ertuğrul, Sögüt, et al., 2001)					
	0.2515 ± 0.0070	(Ertuğral et al., 2007)					
Z = 66, Dy	0.2470 ± 0.0210	(Durak and Özdemir, 1998)	0.2661	0.2741	0.0143	0.0111	0.0043
	0.2630 ± 0.0030	(Ertugrul, Şimşek, et al., 2001)					
	0.2590 ± 0.0210	(Ertuğrul, Sögüt, et al., 2001)					
	0.2460 ± 0.0200	(Han et al., 2007)					
	0.2770 ± 0.0300	(Demir and Şahin, 2007a)					
	0.2780 ± 0.0030	(Demir and Şahin, 2007a)					
	0.2780 ± 0.0030	(Demir and Şahin, 2007a)					
	0.2774 ± 0.0300	(Demir and Şahin, 2007b)					
	0.2779 ± 0.0030	(Demir and Şahin, 2007b)					
	0.2780 ± 0.0030	(Demir and Şahin, 2007b)					
	0.2461 ± 0.0090	(Ertuğral et al., 2007)					
Z = 67, Ho	0.2500 ± 0.0190	(Durak and Özdemir, 1998)	0.2584	0.2606	0.0050	0.0026	0.0015
	0.2600 ± 0.0020	(Ertugrul, Şimşek, et al., 2001)					
	0.2600 ± 0.0210	(Ertuğrul, Sögüt, et al., 2001)					

Table 1 – (*continued*)

Z	Kβ/Kα(exp)	References	$\overline{K\beta/K\alpha}$	$\overline{K\beta/K\alpha}_W$	USD(Kβ/Kα)	WSD (Kβ/Kα)	USE (Kβ/Kα)
	0.2470 ± 0.0200	(Han et al., 2007)					
	0.2590 ± 0.0130	(Demir and Şahin, 2007a)					
	0.2620 ± 0.0040	(Demir and Şahin, 2007a)					
	0.2610 ± 0.0040	(Demir and Şahin, 2007a)					
	0.2596 ± 0.0130	(Demir and Şahin, 2007b)					
	0.2616 ± 0.0040	(Demir and Şahin, 2007b)					
	0.2613 ± 0.0040	(Demir and Şahin, 2007b)					
	0.2609 ± 0.0080	(Ertuğral et al., 2007)					
Z = 68, Er	0.2510 ± 0.0230	(Durak and Özdemir, 1998)	0.2552	0.2597	0.0064	0.0054	0.0029
	0.2610 ± 0.0030	(Ertugrul, Şimşek, et al., 2001)					
	0.2620 ± 0.0210	(Ertuğrul, Sögüt, et al., 2001)					
	0.2470 ± 0.0200	(Han et al., 2007)					
	0.2549 ± 0.0070	(Ertuğral et al., 2007)					
Z = 69, Tm	0.2660 ± 0.0030	(Ertugrul, Şimşek, et al., 2001)	0.2636	0.2646	0.0026	0.0024	0.0015
	0.2640 ± 0.0200	(Ertuğrul, Sögüt, et al., 2001)					
	0.2609 ± 0.0050	(Ertuğral et al., 2007)					
Z = 70, Yb	0.2550 ± 0.0220	(Durak and Özdemir, 1998)	0.2570	0.2587	0.0028	0.0020	0.0020
	0.2589 ± 0.0050	(Ertuğral et al., 2007)					
Z = 71, Lu	0.2669 ± 0.0090	(Ertuğral et al., 2007)	0.2669	0.2669	–	undefined	–
Z = 72, Hf	0.2658 ± 0.0080	(Ertuğral et al., 2007)	0.2579	0.2519	0.0112	0.0079	0.0079
	0.2500 ± 0.0030	(Bennal et al., 2010)					
Z = 73, Ta	0.2610 ± 0.0180	(Durak and Özdemir, 1998)	0.2609	0.2564	0.0099	0.0097	0.0044
	0.2510 ± 0.0040	(Bennal and Badiger, 2006)					
	0.2710 ± 0.0120	(Cevik et al., 2007)					
	0.2704 ± 0.0050	(Ertuğral et al., 2007)					
	0.2510 ± 0.0040	(Bennal et al., 2010)					
Z = 74, W	0.2640 ± 0.0170	(Durak and Özdemir, 1998)	0.2697	0.2709	0.0051	0.0025	0.0030
	0.2740 ± 0.0120	(Cevik et al., 2007)					
	0.2710 ± 0.0050	(Ertuğral et al., 2007)					
Z = 75, Re	0.2684 ± 0.0090	(Ertuğral et al., 2007)	0.2684	0.2684	–	undefined	–
Z = 76, Os	0.2710 ± 0.0080	(Ertuğral et al., 2007)	0.2710	0.2710	–	undefined	–
Z = 77, Ir	0.2724 ± 0.0050	(Ertuğral et al., 2007)	0.2724	0.2724	–	undefined	–
Z = 78, Pt	0.2682 ± 0.0050	(Ertuğral et al., 2007)	0.2682	0.2682	–	undefined	–
Z = 79, Au	0.2620 ± 0.0030	(Bennal and Badiger, 2006)	0.2640	0.2629	0.0035	0.0024	0.0020
	0.2680 ± 0.0050	(Ertuğral et al., 2007)					
	0.2620 ± 0.0030	(Bennal and Badiger, 2006)					
Z = 80, Hg	0.2720 ± 0.0250	(Durak and Özdemir, 1998)	0.2710	0.2649	0.0109	0.0125	0.0055
	0.2794 ± 0.0030	(Ertuğral et al., 2007)					
	0.2553 ± 0.0006	(Yalçin, 2007)					
	0.2772 ± 0.0007	(Yalçin, 2007)					
Z = 81, Tl	0.2695 ± 0.0050	(Ertuğral et al., 2007)	0.2695	0.2695	–	undefined	–
Z = 82, Pb	0.2750 ± 0.0210	(Durak and Özdemir, 1998)	0.2733	0.2692	0.0068	0.0057	0.0034
	0.2680 ± 0.0030	(Bennal and Badiger, 2006)					
	0.2822 ± 0.0070	(Ertuğral et al., 2007)					
	0.2680 ± 0.0030	(Bennal and Badiger, 2006)					
Z = 83, Bi	0.2950 ± 0.0140	(Cevik et al., 2007)	0.2923	0.2912	0.0038	0.0027	0.0027
	0.2896 ± 0.0090	(Ertuğral et al., 2007)					
Z = 86, Rn	0.2606 ± 0.0012	(Yalçin, 2007)	0.2727	0.2717	0.0170	0.0121	0.0121
	0.2847 ± 0.0013	(Yalçin, 2007)					
Z = 90, Th	0.3141 ± 0.0100	(Ertuğral et al., 2007)	0.3141	0.3141	–	undefined	–
Z = 92, U	0.3152 ± 0.0090	(Ertuğral et al., 2007)	0.3152	0.3152	–	undefined	–

Tugluoglu, and Mutlu (2007) measured the Kβ-to-Kα X-ray intensity ratio of ^{28}Ni using an annular ^{109}Cd radioisotope source having 10 mCi activity with planar Si(Li) detector. The Kβ-to-Kα X-ray intensity ratios for 59 elements in the range 16 ≤ Z ≤ 92 were measured by Ertuğral et al. (2007) and the samples are irradiated by 5.9, 59.5 and 123.6 keV photons emitted from annular 1.85 GBq ^{55}Fe, ^{241}Am and 0.925 GBq ^{57}Co radioactive sources, respectively. Yalçin (2007) presented the experimental Kβ/Kα intensity ratios for elements in the range 23 ≤ Z ≤ 86 using the 59.5 keV γ-rays from ^{241}Am to 123.6 keV γ-rays from ^{60}Co, respectively. Ertuğral (2007) determined the K X-ray production cross sections, K-shell fluorescence yields and Kβ-to-Kα X-ray intensity ratios using the 123.6 keV photons emitted from the ^{57}Co radioisotope source for some elements in the range 58 ≤ Z ≤ 64. K shell fluorescence parameters of ^{42}Mo, ^{47}Ag, ^{48}Cd, ^{49}In and ^{50}Sn were measured by Bennal and Badiger (2007) using a weak gamma source. Porikli and Kurucu (2008) reported the Kβ/Kα intensity ratio values for ^{27}Co and ^{28}Ni used γ-photons at 123.6 keV from ^{57}Co annular source at external magnetic field. Timmaraju and Premachand (2009) measured the Kβ/Kα intensity ratio of ^{56}Ba using 59.6 keV gamma rays from ^{241}Am radioactive isotope. Kup Aylikci et al. (2009) measured the Kβ-to-Kα intensity ratios, K X-ray production cross sections and K-shell fluorescence yields of ^{27}Co and ^{29}Cu using two source (50 mCi ^{55}Fe and 50 mCi ^{241}Am) at excitation energies 5.96 keV and 59.5 keV respectively. Kβ-to-Kα intensity ratios of ^{27}Co and ^{29}Cu were measured by Han and Demir (2010) using 22.69 keV photons from a ^{109}Cd radioactive point source. The experimental values of Kβ-to-Kα intensity ratios were obtained in the region $42 \leq Z \leq 82$ by Bennal, Niranjan, and Badiger (2010) using 123.6 keV gamma photons from a weak ^{57}Co source. K-shell X-ray fluorescence parameters and radiative Auger ratios for ^{27}Co and ^{30}Zn were measured by Kup Aylikci, Aylikci, Cengiz, and Apaydin (2010), Kup Aylikci et al. (2011) for the pure metals and in the alloy compositions using the 59.5 keV γ-rays from a ^{241}Am annular radioactive source.

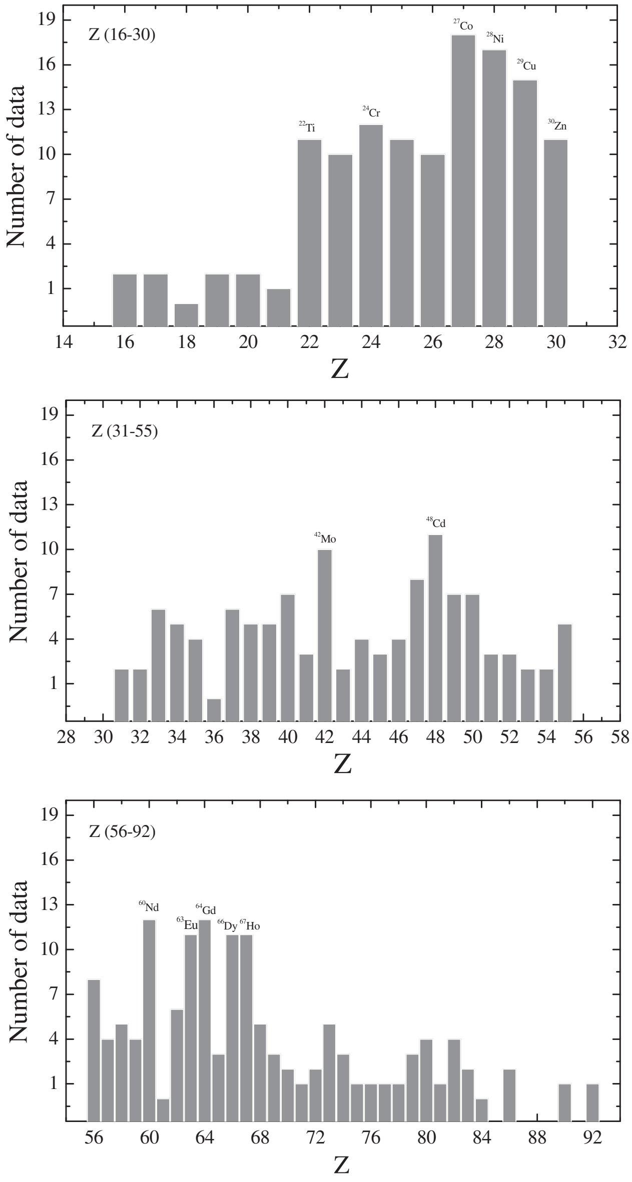

Fig. 1 – Distribution of the experimental Kβ/Kα intensity ratios as a function of atomic number.

3. Data analysis

All of the Kβ/Kα intensity ratio values obtained by photon excitation were taken from the referenced articles. These reported values were taken in a fourth-digit format with their associated errors. The cited experimental results that the uncertainties were not reported in the original sources were rejected. Table 1 reported a summary of the compiled database of Kβ/Kα intensity ratios for elements from ^{16}S to ^{92}U according to their target atomic numbers. The references, from which the databases are extracted, were also listed. In this table, we presented also the unweighted average value:

$$\overline{K\beta/K\alpha} = \frac{\sum_{i=1}^{N} (K\beta/K\alpha)_i}{N} \tag{1}$$

where $(K\beta/K\alpha)_i$ is the experimental intensity ratio and N is the number of experimental data.

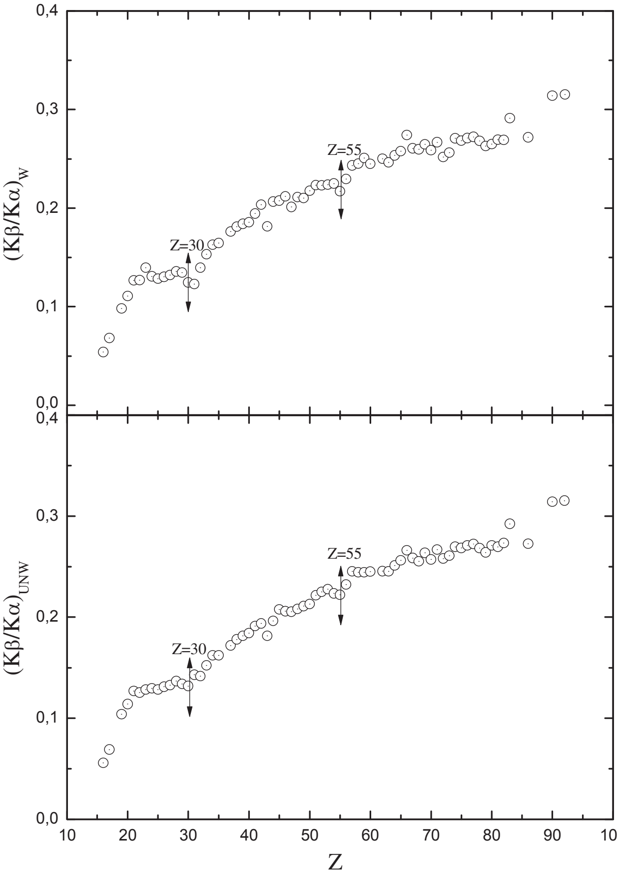

Fig. 2 – Experimental weighted- and unweighted-mean values of Kβ/Kα intensity ratios as a function of atomic number and the representation of the division Z-range.

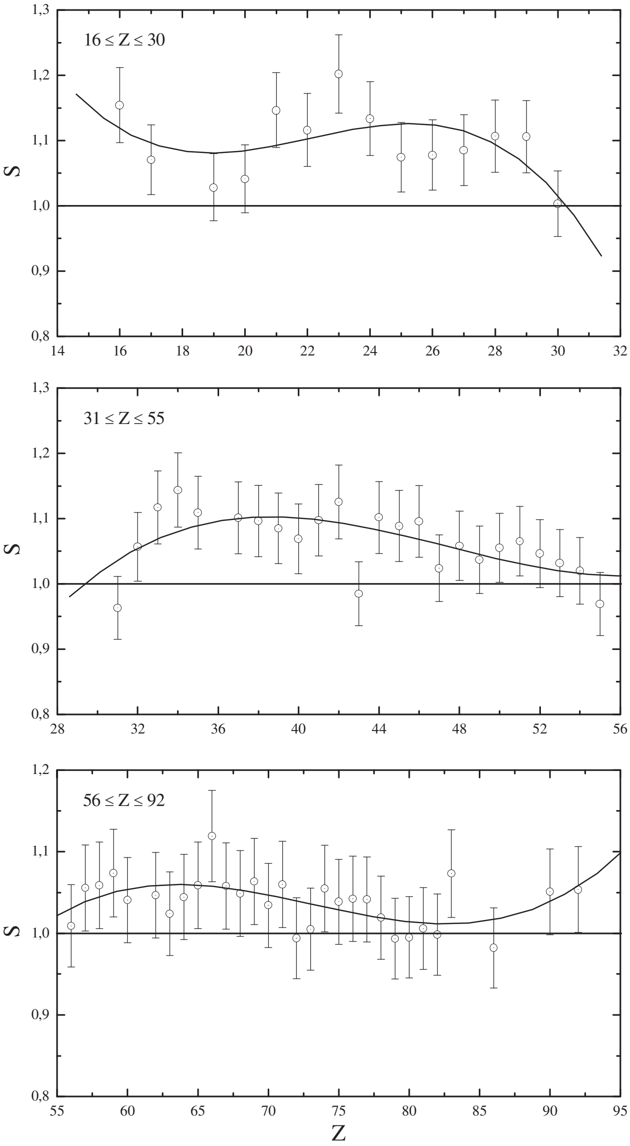

Fig. 3 – Distribution of the normalized experimental weighted-mean values of the Kβ/Kα intensity ratios S=(Kβ/Kα)$_W$/(Kβ/Kα)$_{Scofield}$ in the range of 16 ≤ Z ≤ 30, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92 as a function of atomic number. The curve including the error bars is fitted according to Eq. (6).

The weighted average value:

$$\overline{(K\beta/K\alpha)}_W = \left(\sum_{i=1}^{N}\left(\Delta(K\beta/K\alpha)_i\right)^{-2}\right)^{-1}\sum_{i=1}^{N}\left[\frac{(K\beta/K\alpha)_i}{\left(\Delta(K\beta/K\alpha)_i\right)^2}\right] \tag{2}$$

With, $\Delta(K\beta/K\alpha)_i$ represents the uncertainty of the ith experimental value.

The unweighted standard deviation:

$$USD\ (K\beta/K\alpha) = \sqrt{\frac{1}{(N-1)}\sum_{i=1}^{N}\left((K\beta/K\alpha)_i - \overline{K\beta/K\alpha}\right)^2} \tag{3}$$

Table 2 – Fitting coefficients for the calculation of the semiempirical Kβ/Kα intensity ratios using weighted average value ($\overline{K\beta/K\alpha}_W$).

Z-range	Parameters	Values	ε_{rms}
16 ≤ Z ≤ 30	b_0	4.614810	0.0580
	b_1	−0.49764	
	b_2	0.02299	
	b_3	-3.46677×10^{-4}	
31 ≤ Z ≤ 55	b_0	−2.14741	0.0507
	b_1	0.21842	
	b_2	−0.00477	
	b_3	3.35832×10^{-5}	
56 ≤ Z ≤ 92	b_0	−4.08571	0.0481
	b_1	0.21774	
	b_2	−0.00303	
	b_3	1.38181×10^{-5}	

The weighted standard deviation:

$$WSD(K\beta/K\alpha) = \sqrt{\left(\sum_{i=1}^{N}\left(\Delta(K\beta/K\alpha)_i\right)^{-2}\right)^{-1}\sum_{i=1}^{N}\left[\frac{\left((K\beta/K\alpha)_i - \overline{K\beta/K\alpha}\right)^2}{\left(\Delta(K\beta/K\alpha)_i\right)^2}\right]} \tag{4}$$

The unweighted standard errors:

$$USE(K\beta/K\alpha) = \frac{USD(K\beta/K\alpha)}{\sqrt{N}} \tag{5}$$

The remarkable spread of experimental data for some elements can be attributed to the large number of references used to collect the data (41 papers) and to the different experimental conditions in which the various experiments are performed. Fig. 1 gives the distribution of these data according to their target atomic number. The examination of the figure requires some comments, namely:

- Nearly all of the elements from ^{16}S to ^{92}U are covered except nine elements such as ^{18}Ar, ^{36}Kr, ^{61}Pm, ^{84}Po, ^{85}At, ^{87}Fr, ^{88}Ra, ^{89}Ac and ^{91}Pa because data for these elements are not yet reported due to the fact that they are difficult to handle.
- There are some isolated cases with the data are less than two values.
- The metallic targets and the medium-Z elements are the most exploited and comport the largest numbers of data.
- For the rest of the target atomic numbers, it can be concluded that the Kβ/Kα intensity ratios data are quite well covered. So, it has been obtained a huge database regrouping 369 values for Kβ/Kα intensity ratios.

4. Weighted means parameterization

In our recent paper Kup Aylikci et al. (2011); it was presented two new methods for the calculation of the Kβ-to-Kα intensity ratios, we have calculated the intensity ratios for eight elements (23 ≤ Z ≤ 30) only and we have not used a large number of data compared to this paper. In this paper we calculate the

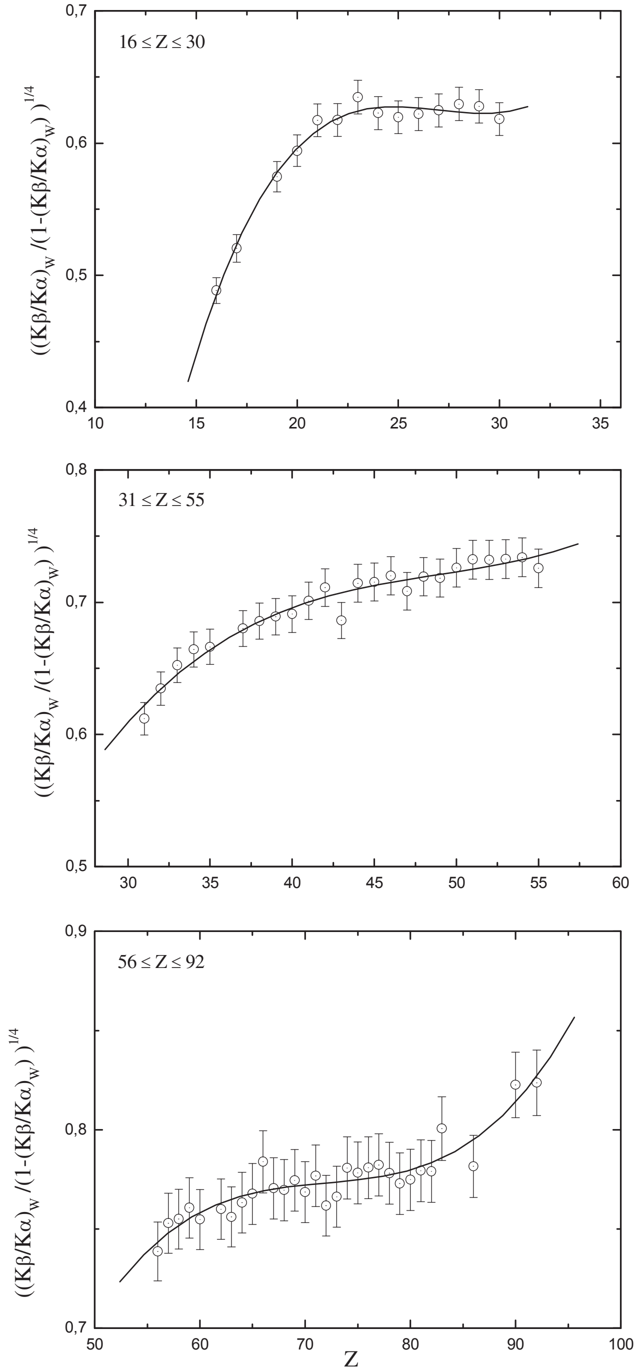

Fig. 4 – Distribution of the experimental weighted-mean values of the Kβ/Kα intensity ratios $\left(\frac{(K\beta/K\alpha)_W}{1-(K\beta/K\alpha)_W}\right)^{1/4}$ in the range of 16 ≤ Z ≤ 55, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92 as a function of atomic number. The curve including the error bars is fitted according to Eq. (7).

Table 3 – Fitting coefficients for the calculation of the empirical Kβ/Kα intensity ratios using weighted average value ($\overline{K\beta/K\alpha_W}$).

Z-range	Parameters	Values	ε_{rms}
$16 \le Z \le 30$	b_0	−1.67244	0.0407
	b_1	0.25886	
	b_2	−0.00966	
	b_3	1.19271×10^{-4}	
$31 \le Z \le 55$	b_0	−0.67945	0.0498
	b_1	0.08210	
	b_2	−0.00164	
	b_3	1.11896×10^{-5}	
$56 \le Z \le 92$	b_0	−1.29494	0.0467
	b_1	0.08534	
	b_2	−0.00118	
	b_3	5.46968×10^{-6}	

Kβ-to-Kα intensity ratios for elements with 16 ≤ Z ≤ 92 used a large number of data. The empirical method (Kup Aylikci et al., 2011) was based on both theoretical values calculated using the relativistic Hartree-Slater theory taken from the paper of Scofield (Scofield, 1974) and experimental values of Kβ/Kα intensity ratios taken from 41 published article (can be seen at Table 1). On the other hand, the experimental data of the Kβ/Kα intensity ratios was directly interpolated to deduce the empirical calculation. So it was used those two methods to calculated semi-empirical and empirical Kβ/Kα intensity ratios. The database in the present work is based on the experimental data for photon excitation published during the period from 1980 till 2011. It has been used the weighted mean values taken from the fifth column of Table 1 to calculate the semiempirical and empirical Kβ/Kα intensity ratios.

4.1. *Semiempirical calculation*

In order to perform a suitable parameterization to deduce the reliable semiempirical intensity ratio values, the atomic range 16 ≤ Z ≤ 92 has been divided into three Z-groups: 16 ≤ Z ≤ 30, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92 this is related to the distribution of the experimental data and this is due to the different methods of measurement (the different methods of measurement are discussed in Section 2). Fig. 2 presents the distribution of the weighted means values of intensity ratio according to the atomic number Z and the three Z-groups has been determined using the same figure. First, the weighted means values of Kβ/Kα intensity ratios were compared with the theoretical values of Scofield (1974) for the three Z-groups: 16 ≤ Z ≤ 30, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92 separately by plotting the ratios S = $(K\beta/K\alpha)_{W-exp}/(K\beta/K\alpha)_{Scofield}$ where $(K\beta/K\alpha)_{Scofield}$ refers the theoretical intensity ratio calculated by Scofield (1974) using the Hartree-Slater theory and $(K\beta/K\alpha)_{W-exp}$ are the weighted means experimental values. Then, S has been plotted as a function of the atomic number Z for each Z-group separately. Fig. 3 shows all points S vs. Z. Each set of these data is fitted by a third degree polynomial (noted as $\overline{S}$), as: $\overline{S} = \sum_{n=0}^{3} b_n Z^n$. The fitting result is also shown in Fig. 3 with a full line. Then, the semiempirical Kβ/Kα intensity ratios have been deduced as follow:

$$(K\beta/K\alpha)_{s-emp} = (K\beta/K\alpha)_{Scofield}\overline{S} \tag{6}$$

The fitting coefficients of $\overline{S}$ for the three Z-groups are listed in Table 2.

4.2. *Empirical calculation*

A new empirical formula has been proposed by our research group (Kup Aylikci et al., 2011). So we used this empirical

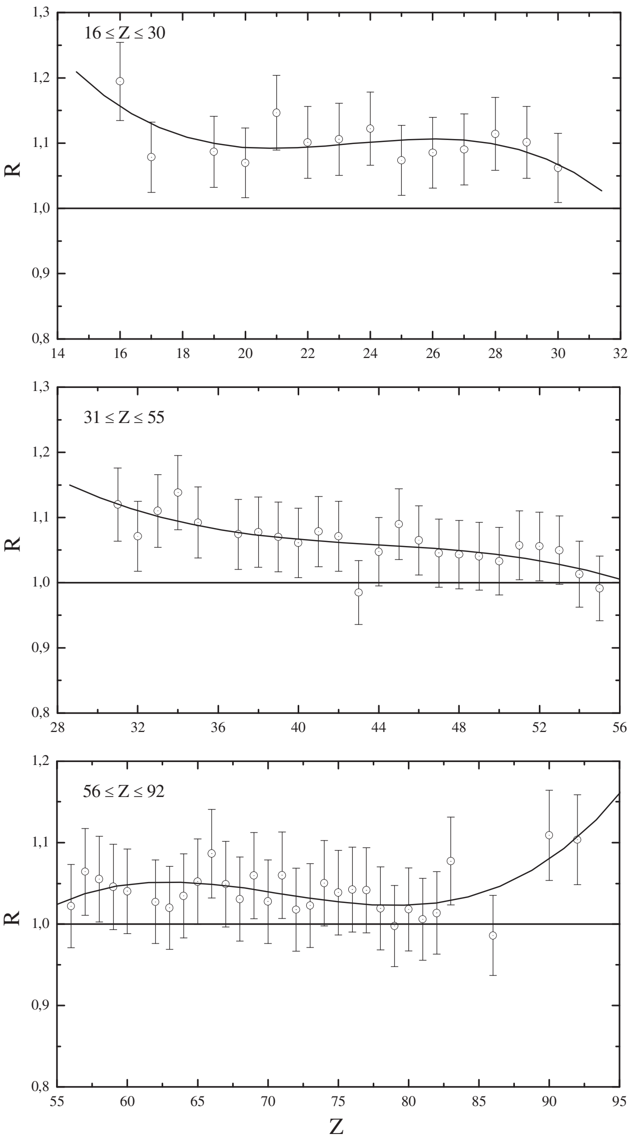

Fig. 5 – Distribution of the normalized experimental unweighted-mean values of the Kβ/Kα intensity ratios R=$(K\beta/K\alpha)_{UNW}/(K\beta/K\alpha)_{Scofield}$ in the range of 16 ≤ Z ≤ 30, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92 as a function of atomic number. The curve including the error bars is fitted according to Eq. (8).

method to deduce the empirical Kβ/Kα intensity ratio. First, we presented for each Z-groups separately (16 ≤ Z ≤ 30, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92), the quantity $\left(\frac{(K\beta/K\alpha)_{W-exp}}{1-(K\beta/K\alpha)_{W-exp}}\right)^{1/4}$ vs Z, where $(K\beta/K\alpha)_{W-exp}$ are the same weighted means experimental values used in the semiempirical calculation. The experimental intensity ratio vs the atomic number Z has been presented in Fig. 4. Finally we fitted those experimental values by the expression:

$$\left(\frac{(K\beta/K\alpha)_{W-exp}}{1-(K\beta/K\alpha)_{W-exp}}\right)^{1/4} = \sum_i b_i Z^i \tag{7}$$

to deduced the empirical Kβ/Kα intensity ratios.

The fitting results are presented in Fig. 4 with full lines and the fitting parameters were resumed in Table 3.

5. Unweighted means parameterization

In this section, we reported semiempirical and empirical Kβ/Kα intensity ratios calculated in the same manner used in Section 4 by fitting, for each Z-group 16 ≤ Z ≤ 30, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92 separately, the experimental data used the unweighted-means values (it can be seen from column 4 at Table 1).

5.1. *Semiempirical calculation*

Firstly, we defined the normalized unweighted means values as: $R = (K\beta/K\alpha)_{UNW\text{-}exp}/(K\beta/K\alpha)_{Scofield}$, where $(K\beta/K\alpha)_{UNW\text{-}exp}$ is the unweighted means experimental values (column 4 at Table 1). In Fig. 5 the distribution of the normalized unweighted means values (R) has been presented according to the atomic number Z, for the three Z-groups: 16 ≤ Z ≤ 30, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92 separately. Each set of these group has been fitted by a third degree polynomial (noted $\overline{R}$) as: $\overline{R} = \sum_{n=0}^{3} b_n Z^n$. Finally the semiempirical Kβ/Kα intensity ratios have been deduced as:

$$(K\beta/K\alpha)_{s-emp} = (K\beta/K\alpha)_{Scofield}\overline{R} \tag{8}$$

The fitting results are represented on Fig. 5 with full lines and Table 4 shows all the coefficients b_n.

5.2. *Empirical calculation*

The empirical Kβ/Kα intensity ratios based on Formula (7) has been reported by fitting the same experimental unweighted means values used in Formula (8) for the three Z-groups: 16 ≤ Z ≤ 30, 31 ≤ Z ≤ 55 and 56 ≤ Z ≤ 92 separately, according to the following expression:

$$\left(\frac{(K\beta/K\alpha)_{UNW-exp}}{1-(K\beta/K\alpha)_{UNW-exp}}\right)^{1/4} = \sum_i b_i Z^i \tag{9}$$

Using this formula, the K X-ray intensity ratio can be expressed as:

Table 4 – Fitting coefficients for the calculation of the semiempirical Kβ/Kα intensity ratios using unweighted average value $(\overline{K\beta/K\alpha})$.

Z-range	Parameters	Values	ε_{rms}
16 ≤ Z ≤ 30	b_0	3.72614	0.0577
	b_1	−0.34424	
	b_2	0.01485	
	b_3	-2.10978×10^{-4}	
31 ≤ Z ≤ 55	b_0	2.61346	0.0494
	b_1	−0.10232	
	b_2	0.00228	
	b_3	-1.73036×10^{-5}	
56 ≤ Z ≤ 92	b_0	−3.60885	0.0497
	b_1	0.20168	
	b_2	−0.00288	
	b_3	-1.35173×10^{-5}	

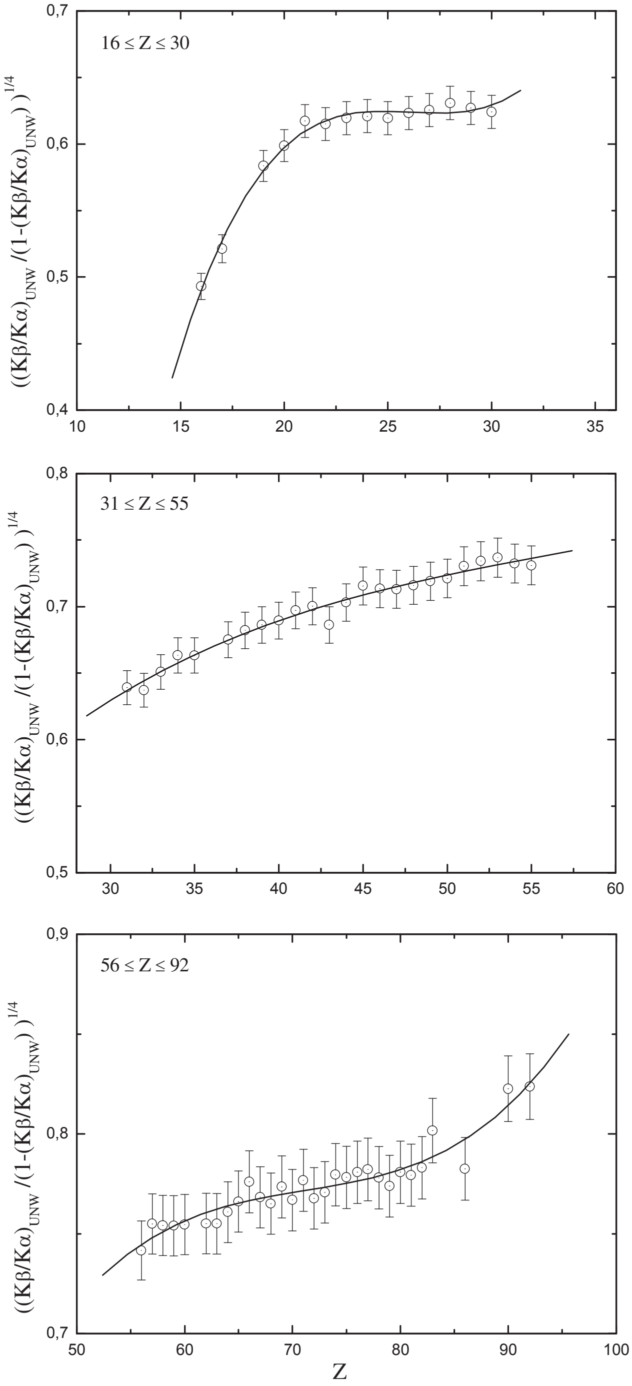

Fig. 6 – Distribution of the experimental unweighted-mean values of the Kβ/Kα intensity ratios $\left(\frac{(K\beta/K\alpha)_{UNW}}{1-(K\beta/K\alpha)_{UNW}}\right)^{1/4}$ in the range of $16 \le Z \le 30$, $31 \le Z \le 55$ and $56 \le Z \le 92$ as a function of atomic number. The curve including the error bars is fitted according to Eq. (9).

$(K\beta/K\alpha) = ((\sum_i b_i Z^i)^4/(1+(\sum_i b_i Z^i)^4))$. The fitting results are also shown in Fig. 6 with full lines. The resulting coefficients are given in Table 5.

Table 5 – Fitting coefficients for the calculation of the empirical Kβ/Kα intensity ratios using unweighted average value $(\overline{K\beta/K\alpha})$.

Z-range	Parameters	Values	ε_{rms}
$16 \le Z \le 30$	b_0	−1.79366	0.0396
	b_1	0.27948	
	b_2	−0.01074	
	b_3	1.37193×10^{-4}	
$31 \le Z \le 55$	b_0	0.13214	0.0409
	b_1	0.02778	
	b_2	-4.55072×10^{-4}	
	b_3	2.72236×10^{-6}	
$56 \le Z \le 92$	b_0	−0.70642	0.0444
	b_1	0.06054	
	b_2	-8.38067×10^{-4}	
	b_3	3.92365×10^{-6}	

It is also noted that the scatter of the data in Figs. 3–6 is partly due to the fact that the data have been taken from the various references and sources performed at different experimental conditions.

The total deviation of the experimental Weighted and Unweighted-means values ($(K\beta/K\alpha)_{W\text{-}exp}$,$(K\beta/K\alpha)_{UNW\text{-}exp}$) from the corresponding calculated values ($(K\beta/K\alpha)(cal)$) is expressed in terms of the root-mean-square error (ε_{rms}) calculated for each z-group using the formula:

$$\varepsilon_{RMS} = \left[\sum_{j=1}^{N} \frac{1}{N}\left(\frac{(K\beta/K\alpha)_j(\exp) - (K\beta/K\alpha)_j(cal)}{(K\beta/K\alpha)_j(cal)}\right)^2\right]^{\frac{1}{2}} \tag{10}$$

where N is the number of the experimental data.

The values of ε_{rms} for the calculation of semiempirical and empirical Kβ/Kα intensity ratios according to the different methods followed here (Formula (6)–(9)) are listed in Tables 2–5 respectively. It is also noted that the error bars of the fitted values of weighted and Unweighted-mean values used in this work have also been represented in Figs. 3–6.

6. Results and discussion

The calculated semiempirical and empirical Kβ/Kα intensity ratios according to the different methods mentioned before (Formula (6)–(9)) in the atomic range $16 \le Z \le 92$ have been tabulated in Table 6. The uncertainties for the semiempirical and empirical results have also been added. It must be emphasized that the fitting of Formula (6)–(9) and the associated coefficients are only valid in the region of atomic number Z ($16 \le Z \le 92$) and the extension out of this region might take an unpredictable course. As seen from Fig. 7 the semiempirical and empirical calculation normalized to their corresponding theoretical calculations of Scofield (1974) and the experimental values of Ertuğral et al. (2007) have been evaluated as a function of the atomic number Z. Despite the quite different procedures have been followed to calculate the X-ray intensity ratios, the obtained results are generally agree with the theoretical and experimental values for middle- and high- atomic number Z ($Z \ge 30$) for weighted- and unweighted-means calculation. The argument in the weighted-means calculation is within the range 1.38%–9.73% for Scofield (1974) and 1.1%–6.09% for Ertuğral et al. (2007) (for the semiempirical intensity ratio) and 1.58%–9.18% for Scofield

Table 6 – Semiempirical and empirical Kβ/Kα intensity ratio deduced from this work.

Z	This work			
	Weighted means		Unweighted means	
	Semiempirical	Empirical	Semiempirical	Empirical
Z = 16, S	0.0522 ± 0.0323	0.0524 ± 0.0339	0.0540 ± 0.0289	0.0547 ± 0.0196
Z = 17, Cl	0.0699 ± 0.0231	0.0693 ± 0.0450	0.0720 ± 0.0147	0.0719 ± 0.0438
Z = 18, Ar	0.0887 ± –	0.0854 ± –	0.0909 ± –	0.0880 ± –
Z = 19, K	0.1034 ± 0.0490	0.0996 ± 0.0114	0.1051 ± 0.0131	0.1019 ± 0.0200
Z = 20, Ca	0.1155 ± 0.0399	0.1113 ± 0.0220	0.1165 ± 0.0038	0.1130 ± 0.0077
Z = 21, Sc	0.1208 ± 0.0495	0.1203 ± 0.0498	0.1208 ± 0.0539	0.1214 ± 0.0449
Z = 22, Ti	0.1254 ± 0.0124	0.1266 ± 0.0067	0.1244 ± 0.0023	0.1270 ± 0.0141
Z = 23, V	0.1292 ± 0.0805	0.1305 ± 0.0079	0.1274 ± 0.0700	0.1303 ± 0.0146
Z = 24, Cr	0.1293 ± 0.0110	0.1323 ± 0.0189	0.1270 ± 0.0119	0.1318 ± 0.0181
Z = 25, Mn	0.1345 ± 0.0455	0.1325 ± 0.0283	0.1320 ± 0.0310	0.1320 ± 0.0281
Z = 26, Fe	0.1358 ± 0.0413	0.1317 ± 0.0191	0.1336 ± 0.0114	0.1316 ± 0.0036
Z = 27, Co	0.1358 ± 0.0262	0.1304 ± 0.0130	0.1345 ± 0.0140	0.1311 ± 0.0132
Z = 28, Ni	0.1343 ± 0.0109	0.1291 ± 0.0143	0.1348 ± 0.0523	0.1311 ± 0.0425
Z = 29, Cu	0.1292 ± 0.0408	0.1283 ± 0.0135	0.1321 ± 0.0486	0.1323 ± 0.0119
Z = 30, Zn	0.1261 ± 0.0129	0.1285 ± 0.0051	0.1325 ± 0.0312	0.1353 ± 0.0259
Z = 31, Ga	0.1328 ± 0.0740	0.1309 ± 0.0024	0.1427 ± 0.0603	0.1414 ± 0.0110
Z = 32, Ge	0.1398 ± 0.0012	0.1399 ± 0.0323	0.1462 ± 0.0021	0.1470 ± 0.0374
Z = 33, As	0.1471 ± 0.0416	0.1483 ± 0.0111	0.1505 ± 0.0328	0.1524 ± 0.0011
Z = 34, Se	0.1546 ± 0.0545	0.1562 ± 0.0441	0.1553 ± 0.0437	0.1575 ± 0.0296
Z = 35, Br	0.1623 ± 0.0139	0.1634 ± 0.0083	0.1608 ± 0.0073	0.1625 ± 0.0025
Z = 36, Kr	0.1701 ± –	0.1700 ± –	0.1665 ± –	0.1673 ± –
Z = 37, Rb	0.1768 ± 0.0035	0.1760 ± 0.0018	0.1716 ± 0.0009	0.1718 ± 0.0004
Z = 38, Sr	0.1830 ± 0.0101	0.1815 ± 0.0087	0.1765 ± 0.0020	0.1762 ± 0.0103
Z = 39, Y	0.1879 ± 0.0208	0.1863 ± 0.0054	0.1805 ± 0.0125	0.1803 ± 0.0064
Z = 40, Zr	0.1922 ± 0.0340	0.1907 ± 0.0002	0.1843 ± 0.0260	0.1843 ± 0.0001
Z = 41, Nb	0.1956 ± 0.0058	0.1945 ± 0.0189	0.1876 ± 0.0001	0.1881 ± 0.0160
Z = 42, Mo	0.1990 ± 0.0231	0.1979 ± 0.0145	0.1910 ± 0.0287	0.1917 ± 0.0110
Z = 43, Tc	0.2018 ± 0.1006	0.2009 ± 0.0653	0.1942 ± 0.0967	0.1951 ± 0.0699
Z = 44, Ru	0.2042 ± 0.0117	0.2036 ± 0.0038	0.1972 ± 0.0147	0.1984 ± 0.0101
Z = 45, Rh	0.2063 ± 0.0057	0.2060 ± 0.0385	0.2000 ± 0.0072	0.2015 ± 0.0306
Z = 46, Pd	0.2079 ± 0.0188	0.2082 ± 0.0174	0.2024 ± 0.0174	0.2045 ± 0.0068
Z = 47, Ag	0.2098 ± 0.0414	0.2102 ± 0.0009	0.2051 ± 0.0432	0.2074 ± 0.0100
Z = 48, Cd	0.2116 ± 0.0019	0.2121 ± 0.0015	0.2078 ± 0.0041	0.2101 ± 0.0096
Z = 49, In	0.2135 ± 0.0156	0.2139 ± 0.0021	0.2105 ± 0.0174	0.2128 ± 0.0087
Z = 50, Sn	0.2157 ± 0.0084	0.2158 ± 0.0015	0.2132 ± 0.0080	0.2153 ± 0.0112
Z = 51, Sb	0.2180 ± 0.0243	0.2177 ± 0.0264	0.2159 ± 0.0257	0.2178 ± 0.0175
Z = 52, Te	0.2205 ± 0.0116	0.2198 ± 0.0302	0.2185 ± 0.0150	0.2202 ± 0.0222
Z = 53, I	0.2232 ± 0.0021	0.2221 ± 0.0303	0.2209 ± 0.0073	0.2226 ± 0.0226
Z = 54, Xe	0.2263 ± 0.0060	0.2246 ± 0.0012	0.2231 ± 0.0011	0.2249 ± 0.0067
Z = 55, Cs	0.2293 ± 0.0534	0.2276 ± 0.0128	0.2249 ± 0.0459	0.2272 ± 0.0230
Z = 56, Ba	0.2346 ± 0.0224	0.2347 ± 0.0053	0.2335 ± 0.0226	0.2352 ± 0.0124
Z = 57, La	0.2396 ± 0.0149	0.2390 ± 0.0301	0.2380 ± 0.0177	0.2385 ± 0.0280
Z = 58, Ce	0.2423 ± 0.0118	0.2428 ± 0.0170	0.2403 ± 0.0101	0.2415 ± 0.0119
Z = 59, Pr	0.2456 ± 0.0211	0.2461 ± 0.0045	0.2432 ± 0.0190	0.2442 ± 0.0003
Z = 60, Nd	0.2484 ± 0.0139	0.2491 ± 0.0032	0.2457 ± 0.0164	0.2467 ± 0.0071
Z = 61, Pm	0.2510 ± –	0.2517 ± –	0.2479 ± –	0.2488 ± –
Z = 62, Sm	0.2533 ± 0.0125	0.2539 ± 0.0181	0.2499 ± 0.0150	0.2508 ± 0.0215
Z = 63, Eu	0.2552 ± 0.0348	0.2558 ± 0.0251	0.2516 ± 0.0373	0.2525 ± 0.0287
Z = 64, Gd	0.2574 ± 0.0156	0.2575 ± 0.0106	0.2537 ± 0.0159	0.2541 ± 0.0122
Z = 65, Tb	0.2582 ± 0.0016	0.2589 ± 0.0073	0.2543 ± 0.0041	0.2555 ± 0.0028
Z = 66, Dy	0.2594 ± 0.0568	0.2600 ± 0.0419	0.2554 ± 0.0541	0.2567 ± 0.0365
Z = 67, Ho	0.2604 ± 0.0008	0.2610 ± 0.0079	0.2564 ± 0.0015	0.2579 ± 0.0021
Z = 68, Er	0.2612 ± 0.0056	0.2618 ± 0.0076	0.2571 ± 0.0080	0.2589 ± 0.0143
Z = 69,Tm	0.2617 ± 0.0110	0.2625 ± 0.0227	0.2577 ± 0.0081	0.2599 ± 0.0144
Z = 70, Yb	0.2623 ± 0.0136	0.2631 ± 0.0054	0.2584 ± 0.0166	0.2608 ± 0.0144
Z = 71,Lu	0.2632 ± 0.0141	0.2636 ± 0.0288	0.2594 ± 0.0126	0.2616 ± 0.0201
Z = 72, Hf	0.2639 ± 0.0456	0.2641 ± 0.0095	0.2604 ± 0.0461	0.2625 ± 0.0176
Z = 73, Ta	0.2648 ± 0.0316	0.2646 ± 0.0019	0.2614 ± 0.0309	0.2634 ± 0.0095
Z = 74, W	0.2656 ± 0.0200	0.2651 ± 0.0275	0.2625 ± 0.0219	0.2643 ± 0.0202
Z = 75, Re	0.2663 ± 0.0079	0.2657 ± 0.0186	0.2635 ± 0.0102	0.2654 ± 0.0115
Z = 76, Os	0.2670 ± 0.0148	0.2664 ± 0.0242	0.2646 ± 0.0173	0.2665 ± 0.0171
Z = 77, Ir	0.2677 ± 0.0174	0.2672 ± 0.0252	0.2657 ± 0.0193	0.2677 ± 0.0177

(continued on next page)

Table 6 – (*continued*)

Z	This work			
	Weighted means		Unweighted means	
	Semiempirical	Empirical	Semiempirical	Empirical
Z = 78, Pt	0.2686 ± 0.0015	0.2682 ± 0.0044	0.2670 ± 0.0002	0.2690 ± 0.0030
Z = 79, Au	0.2695 ± 0.0244	0.2695 ± 0.0164	0.2684 ± 0.0243	0.2705 ± 0.0242
Z = 80, Hg	0.2706 ± 0.0109	0.2709 ± 0.0036	0.2700 ± 0.0221	0.2722 ± 0.0045
Z = 81, Tl	0.2719 ± 0.0088	0.2726 ± 0.0091	0.2720 ± 0.0114	0.2742 ± 0.0170
Z = 82, Pb	0.2734 ± 0.0154	0.2746 ± 0.0030	0.2741 ± 0.0198	0.2763 ± 0.0109
Z = 83, Bi	0.2751 ± 0.0585	0.2770 ± 0.0570	0.2765 ± 0.0512	0.2787 ± 0.0487
Z = 84, Po	0.2771 ± –	0.2797 ± –	0.2793 ± –	0.2814 ± –
Z = 85, At	0.2793 ± –	0.2829 ± –	0.2823 ± –	0.2845 ± –
Z = 86, Rn	0.2819 ± 0.0362	0.2865 ± 0.0455	0.2857 ± 0.0517	0.2878 ± 0.0526
Z = 87, Fr	0.2848 ± –	0.2906 ± –	0.2895 ± –	0.2916 ± –
Z = 88, Ra	0.2878 ± –	0.2952 ± –	0.2934 ± –	0.2957 ± –
Z = 89, Ac	0.2911 ± –	0.3004 ± –	0.2978 ± –	0.3003 ± –
Z = 90, Th	0.2949 ± 0.0651	0.3062 ± 0.0380	0.3026 ± 0.0258	0.3053 ± 0.0289
Z = 91, Pa	0.2987 ± –	0.3126 ± –	0.3074 ± –	0.3108 ± –
Z = 92, U	0.3029 ± 0.0407	0.3197 ± 0.0078	0.3128 ± 0.0142	0.3168 ± 0.0049

(1974) and 0.04%–6.36% for Ertuğral et al. (2007) (for the empirical calculation). For the unweighted-means calculation is in the range of 0.4%–10.51% for Scofield (1974) and 0.09%–6.8% for Ertuğral et al. (2007) (for the semiempirical intensity ratio) and 1.41%–10.13% for Scofield (1974) and 0.29%–9.09% for Ertuğral et al. (2007) (for the empirical calculation). The relative difference between the obtained semiempirical, empirical and the other calculation values have been evaluated using the equation $RD\,(\%) = \left|((K\beta/K\alpha) - (K\beta/K\alpha)_{emp,s-emp})/(K\beta/K\alpha)_{emp,s-emp}\right| \times 100$), whereas some differences have been observed with the decreasing of atomic number Z (Z < 30). It has been observed a disagreement of 11.15% for Scofield (1974) and 13.22% for Ertuğral et al. (2007) (for the semiempirical intensity ratio) and 12.85% for Scofield (1974) and 13.05% for Ertuğral et al. (2007) (for the empirical calculation) for the weighted-means calculation, and for the unweighted-means calculation it has been observed 13.52% for Scofield (1974) and 9.44% for Ertuğral et al. (2007) (for the semiempirical intensity ratio) and 14.62% for Scofield (1974) and 10.5% for Ertuğral et al. (2007) (for the empirical calculation). It is thought that this disagreement in this region is due to the Kβ/Kα X-ray intensity ratio values are small ranging from 0.0470 for ^{16}S and 0.1200 for ^{30}Zn. The measurements in this range introduce a supplementary uncertainty on the intensity ratios than the range of heavy elements. Also this disagreement is due to the different effective weighting in the two approaches (semiempirical and empirical) in which the spread of the experimental data is expected to be the main reason. In fact, the calculation of the semi-empirical values is based on both theoretical (the theoretical calculation of Scofield based on the Hartree-Slater theory) and experimental values via the fitting of the S and R parameters while the experimental data are only used for the empirical calculation.

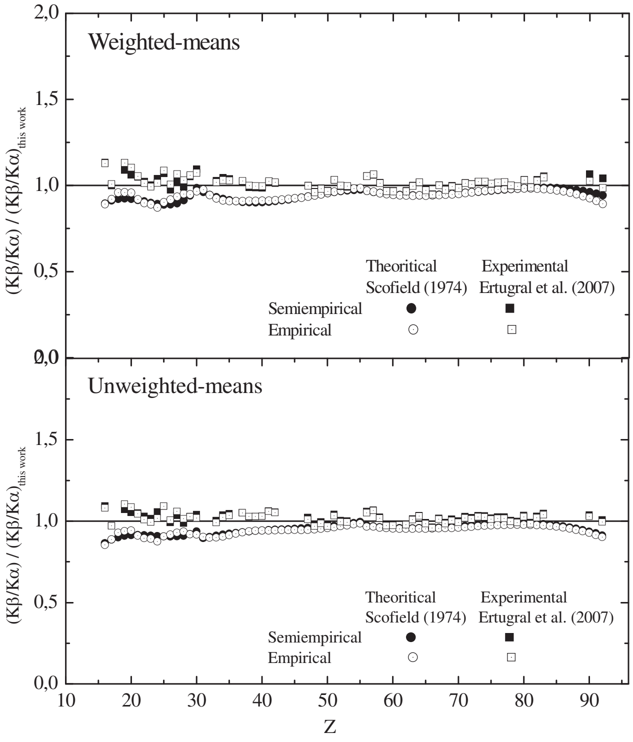

Fig. 7 – Theoretical values of Scofield (1974) and the experimental values of Ertuğral et al (2007) as a function of atomic number. All these values are normalized to their corresponding semiempirical and empirical calculations (This work).

7. Conclusion

In this contribution, it has been presented the measurements Kβ/Kα X-ray intensity ratios by photons excitation published in the period 1980 to 2011 with a table form (about 369 data) and it has been reported the semi-empirical and empirical Kβ/Kα X-ray intensity ratios with their corresponding fitting parameters, which are only valid in the region of the used in the range of Z (16 ≤ Z ≤ 92). The deduced semi-empirical and empirical intensity ratios present a good compromise between the theoretical and experimental values for the whole range of used atomic numbers. In this article, the new intensity ratio values have been given in the field of atomic inner-shell ionization processes in addition to the available experimental and theoretical intensity ratios.

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