

A STUDY OF THE EFFECTIVE ATOMIC NUMBER OF $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ TERNARY ALLOYS FOR PHOTONS

by

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The effective atomic number (Z_{eff}) of $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ ternary alloys was obtained for photons. Rayleigh to Compton scattering ratio (R/C) has been determined to obtain the Z_{eff} of $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ ternary alloys of varying Si and Pb (10 %-60 %) content for scattering of 59.54 keV γ -rays at an angle of 130°. The theoretical R/C ratios of elements were plotted as a function of the atomic number and fitted to a polynomial equation. Experimental R/C values of alloys were then used to obtain Z_{eff} using this fit equation. Also, Z_{eff} values of these alloys were determined for the first time by interpolating the R/C of the material using the R/C data of adjacent elements in between the R/C of the alloy lies. The agreement between the interpolation method and the fit equation was quite satisfactory. The obtained Z_{eff} for photon scattering were then compared to the Z_{eff} for total photon attenuation obtained using the Auto- Z_{eff} program. Significant variations were observed between the Z_{eff} for scattering and the total attenuation of gamma rays.

Key words: effective atomic number, ternary alloy, scattering, charged particle

INTRODUCTION

Ferro alloys are known as various alloys of iron including one or more other elements such as copper, nickel, chromium, manganese, aluminum or silicon which are used in the production of steels and alloys. The said alloys are of use in nuclear engineering, industry, stainless steels, reactors, shielding technologies (especially lead-doped ferro alloys) [1, 2]. Thus, knowledge of their radiation related physical parameters such as mass attenuation coefficients, stopping power factors (for charged particles), effective atomic number and electron density is very important for understanding their behavior under the charged and uncharged radiation interaction. The interactions of photons as well as charged particles are of key importance whether as primary or secondary radiation since various applications in which ionizing radiations are involved take into account radiation interaction properties of the materials in different energy regions. Unlike the elements, a single number cannot represent the multi element material in the continuous energy region as expressed by Hine [3]. Because it contains elements with different atomic numbers and for each of the pro-

cesses by which radiation interacts with matter, the various atomic numbers in the material have to be weighted differently. Accordingly, Z_{eff} is not a true constant for a given material but varies with energy, depending on the interaction processes involved.

Referring to literature, experiments based on photon attenuation have been widely used to determine the Z_{eff} of alloys. A non-destructive technique based on the scattering of photons has also been used to obtain the Z_{eff} of alloys, although not as extensively as for the attenuation of photons. Singh *et al.* [4] measured the effective atomic number of brass and bronze composites (composition of alloys; Cu-70 %, Zn-30 % and Cu-60 %, Sn-40 %) using the Rayleigh to Compton scattering ratio of 145 keV photon energy at a 70° scattering angle. The effective atomic number of composite materials of known composition such as brass, bronze, soldering material, perspex, and bakelite were studied using the Rayleigh to Compton scattering ratio of 279 keV γ -rays at a 50° scattering angle [5]. Singh *et al.* [6] determined the effective atomic number of some binary alloys using multiple scattering of 662 keV gamma rays and have utilized the Rayleigh to Compton scattering ratio for the 145 keV photon energy to determine the effective atomic number of Pb-Sn alloys (7). Kumar and Umesh [8] measured the

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effective atomic number of composite materials for the gamma ray region of 280-1115 keV at different scattering angles. Demir and Tursucu [9] investigated the effective atomic number of FeCr and FeNi binary ferro alloys using the Rayleigh to Compton scattering ratio of 59.54 keV photon energy at a 167° scattering angle. Yilmaz et al. [10] measured the effective atomic number of gunshot residues (composed of Pb-Sb, Cu-Zn alloys and nitrocellulose) using the Rayleigh to Compton scattering ratio of 59.54 keV photon energy. Effective atomic numbers for various materials have been previously studied as well [11-14].

In the present study, a ternary (lead-ferro silicon) alloy $Si_xPb_{0.7-x}(Fe_2O_3)_{0.3}$ has been used to investigate radiation interaction characteristics since iron is being used as a structural material in nuclear reactors along with the high Z element, lead is being used as a radiation shielding material. This type of alloy has not been directly used in nuclear technology yet. However, it would be interesting to investigate its radiation interaction behavior since it contains key elements such as Fe and Pb. Therefore, $Si_xPb_{0.7-x}(Fe_2O_3)_{0.3}$ ternary alloys have been investigated with respect to the Z_{eff} for scattering of 59.54 keV gamma rays at a scattering angle of 130°. The experimental geometry shown in fig. 1 allowed the angle of 130° as a scattering angle. This scattering angle was selected in order to investigate the scattering of photons in comparison to the attenuation of photons. Also, an alternative method, namely interpolation, was used to obtain Z_{eff} for the scattering of gamma rays as a means of comparing it with the commonly used fitting procedure for obtaining Z_{eff} . An Am-241 annular mono energetic radioactive source emitting 59.54 keV photons was used in this work. The annular form of the source allowed gamma rays of 59.54 keV to scatter at an angle of 130°. Therefore, the scattering angle has been kept constant, but the concentrations of elements constituting the alloy have been varied. Moreover, the Z_{eff} of the chosen alloys was estimated for different types of interac-

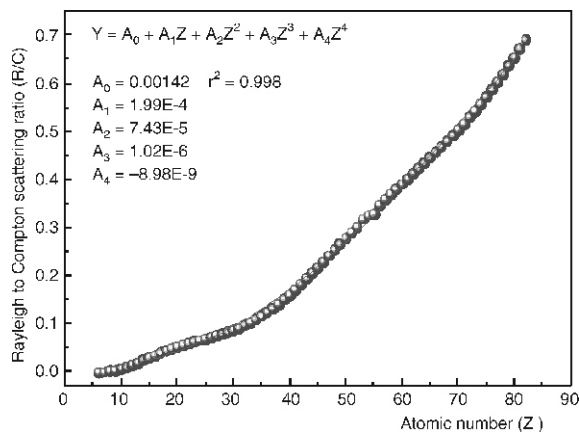


Figure 1. Rayleigh to Compton scattering ratio as a function of the atomic number of elements. Fitting to a fourth order polynomial equation gives best fitting as R^2 is ~1

tions, such as total photon attenuation at 59.54 keV using different methods as well.

METHOD

Z_{eff} for scattering of gamma rays

First method (fitting equations)

In order to determine the Z_{eff} of the chosen alloys, the Rayleigh to Compton scattered photon intensity ratios were used. At a scattering angle of θ , the number of Rayleigh (N_R) and Compton (N_C) photons are directly proportional to the areas of their respective peaks in the measured spectrum. In addition, the scattered intensity ratios can be theoretically calculated using eq. [15]

$$\frac{R}{C}(x, Z) = \frac{N_R}{N_C} \frac{N_0 \eta_{at} \frac{d\sigma}{d\Omega}_R \Delta\Omega V \varepsilon A_R}{N_0 \eta_{at} \frac{d\sigma}{d\Omega}_C \Delta\Omega V \varepsilon A_C} \quad (1)$$

where N_0 is the initial fluence, η_{at} – the number of atoms per volume of the sample, $\Delta\Omega$ – the solid angle subtended by the detector, ε – the detector efficiency, A_R and A_C are the self-attenuation factors for each of the scattering processes, $[d\sigma/d\Omega]_R$ and $[d\sigma/d\Omega]_C$ are differential cross-sections, respectively [15]. If N_R and N_C are measured in the same geometric conditions of irradiation and detection, then N_0 , η_{at} , Ω , V , and ε become constant values. Equation (1) can be rewritten considering the Thomson, $[d\sigma/d\Omega]_{Th}$, and Klein-Nishina, $[d\sigma/d\Omega]_{KN}$, differential cross-sections, the atomic form factor, F , and the incoherent scattering function, S , which are dependent on the momentum transfer ($x = \sin(\theta/2)/\lambda$),

$$\frac{R}{C}(x, Z) = \frac{\frac{d\sigma}{d\Omega}_R A_R}{\frac{d\sigma}{d\Omega}_C A_C} = \frac{\frac{d\sigma}{d\Omega}_{Th} F^2(x, Z) A_R}{\frac{d\sigma}{d\Omega}_{KN} S(x, Z) A_C} \quad (2)$$

The self-attenuation factors for the Rayleigh and Compton intensities can be calculated as

$$A_R = \frac{1}{V} \int_V \exp[-\mu(E_0)L_i - \mu(E_0)L_s] dV$$

and

$$A_C = \frac{1}{V} \int_V \exp[-\mu(E_0)L_i - \mu(E_C)L_s] dV$$

respectively [15]. $\mu(E_0)$ and $\mu(E_C)$ are the linear attenuation coefficients for the incident (E_0) and Compton (E_C) scattered energies, L_i is the distance from the surface of the sample to the elemental scattering volume (dV) and L_s from this element to the surface of the sample, in the direction of the detector [15, 16]. For a fixed

experimental condition, when a small energy shift occurs between Rayleigh and Compton scattering and thus ratio of A_R and A_C becomes 1 ($A_R/A_C = 1$) [15-18]. In this case, eq. (2) can be reduced. However, in the present work there is an energy shift between Rayleigh and Compton scattering, thus the condition $A_R/A_C = 1$ cannot be satisfied. Therefore, self-attenuation correction factors were calculated and properly used in eq. (2). If molecular weight and elemental composition fractions of the given compounds or composite materials are known, R/C is calculated by weighting the atomic percentages α_j^{at} of elements as following [17]

$$\frac{R}{C}(x, Z) = \frac{\frac{d\sigma}{d\Omega}_{Th} \sum_{j=1}^n \alpha_j^{at} [F(q, Z_j)]^2}{\frac{d\sigma}{d\Omega}_{KN} \sum_{j=1}^n \alpha_j^{at} S(q, Z_j)} \frac{A_R}{A_C} \quad (3)$$

where α_j^{at} is defined by weight percentage w_j and atomic mass A_j of the j th element as [17]

$$\alpha_j^{at} = \frac{\frac{w_j}{A_j}}{\sum_{j=1}^n \frac{w_j}{A_j}} \quad (4)$$

After the determination of R (theoretically or experimentally), the Z_{eff} can be calculated using the interpolation formula at the same scattering angle and energy as well.

For a fixed momentum transfer, R/C is a function of only the Z of the sample [15, 16, 18-20]. Therefore, theoretical values of R/C can be calculated via eq. (3) and, when plotted in function of Z for pure elements, then the Z_{eff} of the material can be deduced using the best fit equation [15, 16]. Those data were plotted considering the F and S values and their corresponding x moments from Hubbell *et al.* [20, 21] for elements with $25 \leq Z \leq 70$, as shown in fig. 1. The continuous line is the result of the best polynomial fit. The equation for the best-fit curve is shown as well (fig. 1).

Second method (interpolation)

Z_{eff} of the chosen alloys can be estimated using a well-known interpolation procedure shown below [22]

$$Z_{eff} = \frac{Z_1 (\log R_2 - \log R) + Z_2 (\log R - \log R_1)}{\log R_2 - \log R_1} \quad (5)$$

where R_1 and R_2 are the R/C ratios in between the R of the material lies and Z_1 and Z_2 are atomic numbers of the elements corresponding to the ratios (R/C) R_1 and R_2 , respectively. The use of the above interpolation method in scattering experiments has been explained in detail elsewhere [23].

Z_{eff} for total photon attenuation

First method

The Auto- Z_{eff} program was used to calculate the Z_{eff} of the given materials for total photon attenuation at 59.54 keV [24]. It was used to calculate Z_{eff} for multi-energetic photons emitted through heterogeneous radiation sources such as Pd-103, Tc-99, Ra-226, I-131, Ir-192, Co-60, 30 kVp, 40 kVp, 50 kVp (Intrabeam, Carl Zeiss Meditec), and 6 MV (Mohan-6 MV) sources as well.

Second method (single Z_{eff})

A single-valued Z_{eff} was obtained by using Mayneord's formula as follows [12, 14, 25]

$$Z_{eff} = \left(\sum_i \alpha_i Z_i^{2.94} \right)^{1/2.94} \quad (6)$$

where α_i is the fractional number of electrons of element i which can be calculated using the below formula

$$\alpha_i^e = \frac{\frac{w_i}{A_i} Z_i}{\sum_i \frac{w_i}{A_i} Z_i} \quad (7)$$

EXPERIMENTAL

The alloys used in this study were in fine powder form. The concentrations of light and heavy elements have been varied from 10 % to 60 %. Table 1 lists the weight fractions, thicknesses and densities of the chosen alloys. The samples were pelleted using a pressing machine to form tablet samples prior to measurements. The pellets were pressed at 8 tons/cm² in a Spex hy-

Table 1. Elemental composition, thickness and density of the chosen alloys

Alloy	Weight fraction [%]			Density [gcm ⁻³]	Thickness [cm]	R/C	
	Fe ₂ O ₃	Si	Pb			Experiment	Theory
Pb _{0.1} -Si _{0.6} -(Fe ₂ O ₃) _{0.3}	30	60	10	2.84	0.37	0.05	0.06
Pb _{0.2} -Si _{0.5} -(Fe ₂ O ₃) _{0.3}	30	50	20	3.12	0.34	0.09	0.10
Pb _{0.3} -Si _{0.4} -(Fe ₂ O ₃) _{0.3}	30	40	30	3.55	0.31	0.13	0.14
Pb _{0.4} -Si _{0.3} -(Fe ₂ O ₃) _{0.3}	30	30	40	3.89	0.29	0.17	0.18
Pb _{0.5} -Si _{0.2} -(Fe ₂ O ₃) _{0.3}	30	20	50	4.58	0.25	0.21	0.23
Pb _{0.6} -Si _{0.1} -(Fe ₂ O ₃) _{0.3}	30	10	60	5.45	0.21	0.25	0.28

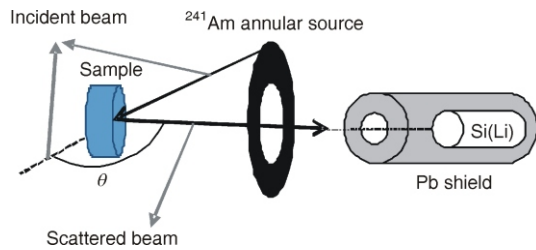


Figure 2. Schematic diagram of the experimental set-up. Incident and scattered beam and representation of scattering angle are included

draulic press. In this way, the samples obtain a smooth surface so that errors due to the improper shape of the samples are minimized. The mass of each alloy was scaled using a scale with a 10^{-5} g accuracy. The experimental arrangement is shown in fig. 2. In order to obtain the Rayleigh/Compton scattering intensity, all alloys were excited using 59.54 keV gamma rays emitted from an Am-241 annular radioactive source (100 mCi). The scattering peaks (Rayleigh and Compton peaks) emitted from the targets were detected by a Si(Li) detector (effective area 12 mm^2 , thickness 3 mm, Be-window thickness 0.025 mm, Canberra SL30165, with energy resolution of 165 eV at 5.9 keV) and analyzed using the Genie-2000 software. The data were collected into 4096 channels of the MCA and further analyzed by the demo version of the Origin 7.5 software program. The counting time for each measurement was kept at 10800 s in order to reduce the statistical uncertainties due to counting statistics, both for Rayleigh and Compton peaks. The scattering angle is 130° , sample-to-source and source-to-detector distances were kept as 10 cm.

RESULTS AND DISCUSSION

The various sources of error in the measurements are due to counting statistics, mass thickness determination and evaluation of photo peak areas by peak fitting, etc. The error in the counting statistics was reduced to $<1\%$ by collecting at least 10^4 counts under the Compton and Rayleigh peaks. By accumulating at least 10^4 counts under the peak, the subsequent uncertainty becomes 1% according to the error propagation formula \sqrt{N}/N , where the number of total counts under the peak is N . The evaluation of the area of scattered peak by peak fitting was done using the demo version of Origin which gives the estimated error as an output as well. The error associated to evaluating the area of the scattered peak by peak fitting routine was less than 3% . Mass thicknesses were measured by a micrometer which could measure down to 0.01 cm. The uncertainty in estimating the mass thickness of the targets was about 1% . The uncertainty in the scattering angle was approximately 1% . The uncertainties in the peak fitting and log-interpolation procedure were based on the derivation of Rayleigh

and Compton cross sections and the atomic form factor and incoherent scattering functions. The uncertainties in $F(x, Z)$ and $S(x, Z)$ were found to be less than 1% [20]. By using the R/C ratio, the sensitivity to sample thickness variation and positioning can be reduced, thus leading to lower experimental uncertainties [17].

Typical scattering spectra for the chosen alloys were shown in fig. 3. It is well-known that Compton scattering is more dominant in low and medium Z materials than in those of high Z . It is obvious that the alloy which has the lowest weight fraction of Pb has the highest Compton peak intensity (fig. 3). Up to now, the Z_{eff} of the materials for gamma scattering has been determined using fitting equations [9, 13, 15-19]. In the present work, an alternative method has been employed to show its availability for estimating Z_{eff} for scattering of gamma rays. For this purpose, two different methods were compared with respect to the obtained Z_{eff} . The R/C of the material and the data of adjacent elements in between the R/C of the material lies were used to interpolate the Z_{eff} of the chosen alloys. Figure 4 shows the relative difference (%) between the experimental and theoretical values of Z_{eff} . The relative differences were found to be $<8\%$ between the experimental and theoretical values of Z_{eff} . Shown in fig. 5 is the relative difference (%) in Z_{eff} obtained using the fitting equation and interpolation formula. An excellent agreement has been observed between the two methods as relative differences (%) were always $<8\%$. Therefore, the interpolation was found to be an alternative and practical method for the calculation of Z_{eff} for scattering of gamma rays.

Besides, for the scattering of gamma rays, the Z_{eff} values of the chosen alloys for total photon attenuation were obtained by using the Auto- Z_{eff} program [24] and a single-valued Z_{eff} , independent of the energy acquired through Mayneour's formula [25]. Total attenuation refers to the sum of attenuations due to each partial interaction process. In the case of

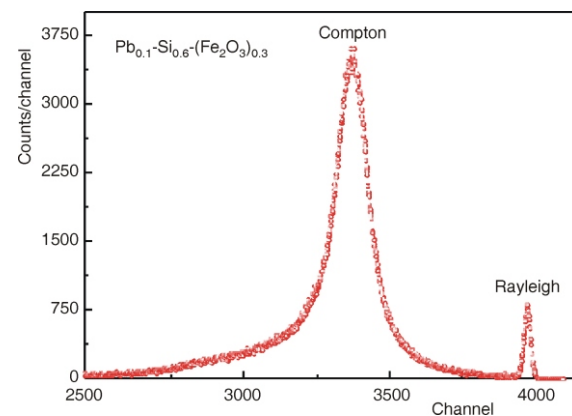


Figure 3. Typical scattering spectra of the chosen alloys at 59.54 keV. Note that the Compton scattering peak has greater intensity than that of Rayleigh scattering due to high weight fraction of lighter elements in the alloy

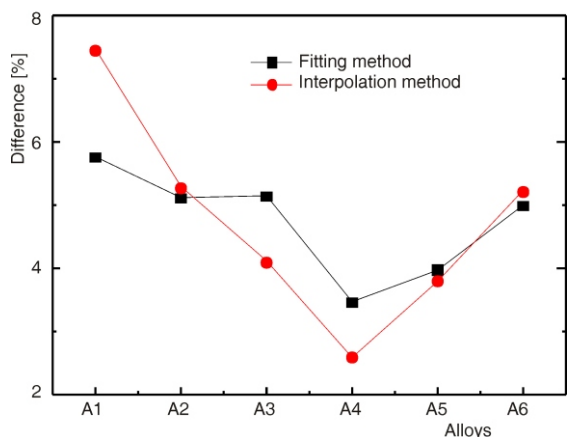


Figure 4. Differences between experimental and theoretical values of Z_{eff} obtained using fitting and interpolation methods. There is an agreement up to a relative difference of 8 %

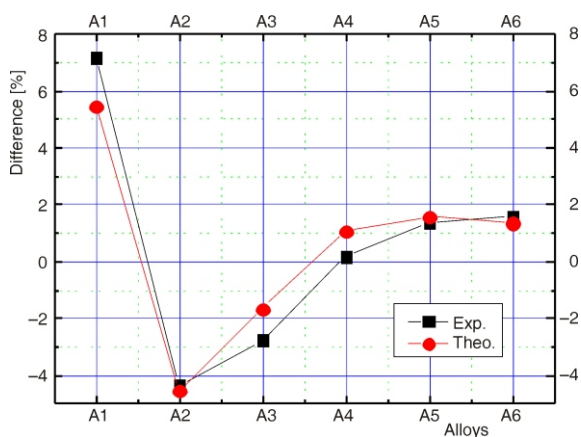


Figure 5. Differences in Z_{eff} between the fitting and interpolation methods. Agreement between the two methods is quite satisfactory (difference <8 %)

photons, the partial interaction mechanisms are photoelectric effect, Compton scattering and pair production. Calculated Z_{eff} values of the selected alloys for the attenuation of gamma rays in the energy region 10 keV-1 GeV and those obtained using Mayneour's formula [25] have been given in tab. 2. Moreover, Z_{eff} values of the chosen alloys have been calculated for

photon radiation sources heterogeneous in energy using Auto- Z_{eff} . Results for heterogeneous radiation sources are given in tab. 3. As can be seen, alloys with higher Pb content possess higher Z_{eff} values. Z_{eff} for photon scattering and total attenuation are shown in fig. 6. For total photon attenuation, Z_{eff} values make a peak around 100 keV due to the high presence of the Z, element, Pb (K-absorption edge ~88 keV) in the alloy fig. 6(a). Single-valued Z_{eff} values for photon attenuation obtained using the empirical formula have been found to increase as the weight fraction of Pb for the chosen alloys increases at 59.54 keV, fig. 6(b). It is well-known that Mayneour's formula gives an energy independent Z_{eff} for any material and that this formula is known to be valid at low photon energies where photoelectric absorption dominates. The highest values of Z_{eff} were obtained through the power law equation, *i. e.* Mayneour's formula, and it has been observed that Z_{eff} increases as the weight fraction of high Z elements increases in the alloy in general (fig. 6).

The higher values of Z_{eff} were observed for photons in the low energy region. This could be due to the fact that at the energy of 59.54 keV the main interaction process is photoelectric absorption for photon interaction and its cross-section is proportional with Z^4 -5 of the elements constituting the alloy. Due to the presence of high Z elements in the alloys, *i. e.* Pb ($Z = 82$), photoelectric absorption becomes more dominant for the chosen alloys at that energy and that could lead to the highest values of Z_{eff} for photon interaction. Therefore, due to the high Z dependence of photon interaction cross-sections, the highest Z_{eff} is observed for photons. As for large differences observed in Z_{eff} for the scattering and attenuation of gamma rays, it has to be noted that the R/C increases sharply as the weight fraction of the high Z element present in the alloy increases (fig. 7). When compared to Compton scattering, the Rayleigh scattering becomes more dominant in this energy region if the material has a high content of the high Z element Pb. This results in a dramatic increase in the Rayleigh scattering cross-section as it has a Z^2 dependence. While the Compton scattering

Table 2. Z_{eff} of the selected alloys for photon scattering and attenuation

Energy [MeV]	A1		A2		A3		A4		A5		A6	
	A ^a	M ^b	A	M	A	M	A	M	A	M	A	M
1.00E-02	17.4	36.5	31.0	45.5	34.2	52.3	36.2	57.9	38.4	62.8	41.0	67.2
5.00E-02	20.9	36.5	24.0	45.5	26.6	52.3	29.2	57.9	32.3	62.8	34.8	67.2
1.00E-01	27.3	36.5	33.2	45.5	37.9	52.3	42.3	57.9	46.6	62.8	51.2	67.2
5.00E-01	17.1	36.5	20.3	45.5	24.2	52.3	28.9	57.9	34.5	62.8	41.2	67.2
1.00E+00	15.9	36.5	17.9	45.5	20.3	52.3	23.3	57.9	27.3	62.8	32.5	67.2
1.00E+01	16.9	36.5	19.3	45.5	22.1	52.3	25.4	57.9	29.3	62.8	34.3	67.2
5.00E+01	17.5	36.5	20.2	45.5	23.3	52.3	26.7	57.9	30.7	62.8	35.7	67.2
1.00E+02	17.6	36.5	20.3	45.5	23.3	52.3	26.8	57.9	30.8	62.8	35.8	67.2
5.00E+02	17.5	36.5	20.3	45.5	23.3	52.3	26.8	57.9	30.9	62.8	35.9	67.2
1.00E+03	17.5	36.5	20.3	45.5	23.3	52.3	26.7	57.9	30.9	62.8	35.9	67.2

^a Refers to the attenuation of photons, ^b Refers to the Mayneour's formula (single Z_{eff})

Table 3. Z_{eff} of the chosen alloys for various photon sources heterogeneous in energy (multi-energetic)

	^{192}Ir	^{60}Co	^{131}I	^{103}Pd	^{226}Ra	^{99}Tc	30 kVp	40 kVp	50 kVp	6 MV
A1*	18.6	15.8	18.6	18.1	22.8	20.1	17.6	18.3	18.7	16.0
A2	23.2	17.6	23.0	20.6	29.1	23.3	20.9	22.0	22.3	18.0
A3	28.0	19.8	27.7	36.9	33.7	33.2	30.6	30.1	29.4	20.4
A4	33.1	22.6	32.8	36.9	39.2	35.3	35.4	34.4	33.4	23.5
A5	38.7	26.3	38.4	44.2	43.3	40.5	39.6	38.3	37.2	27.4
A6	44.6	31.3	45.3	49.0	47.7	44.3	45.2	46.4	45.2	32.7

*A1-A6 refer to $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ with $x = 0.6, 0.5, 0.4, 0.3, 0.2$ and 0.1 , respectively

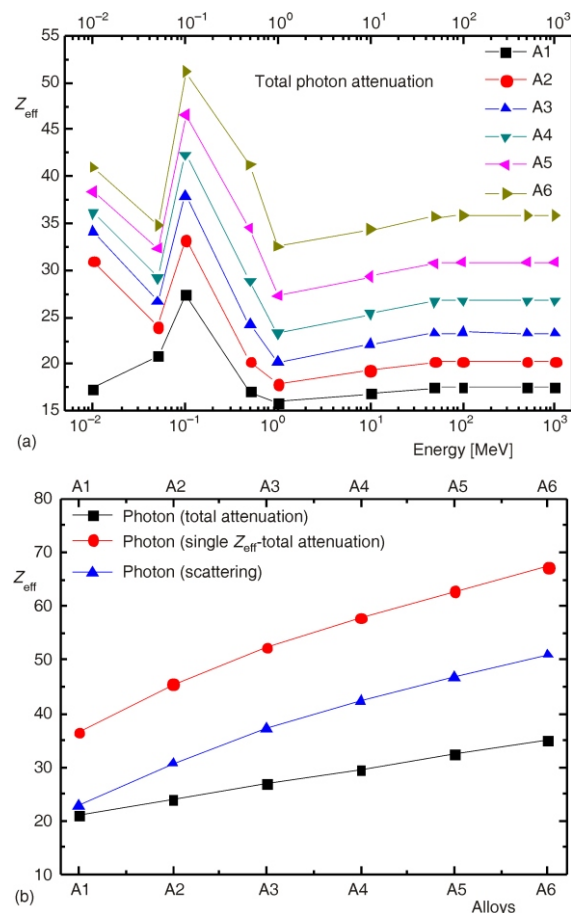


Figure 6. Z_{eff} of the chosen alloys for total photon attenuation (a), for total photon attenuation, photon scattering, and single valued at 59.54 keV of photons (b)

cross-section remains more or less the same for high Z materials, the Rayleigh scattering cross-section increases much more and thus generates a high ratio of R/C . This could be the reason for observing large differences in Z_{eff} between the scattering and attenuation of photons.

CONCLUSION

In the present work, the effective atomic numbers (Z_{eff}) of $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ ternary alloys were obtained for scattering of gamma rays and total photon attenuation. In the experimental part of the paper, the Rayleigh to Compton scattering ratio (R/C) has been used to obtain the Z_{eff} of $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ ternary alloys for scatter-

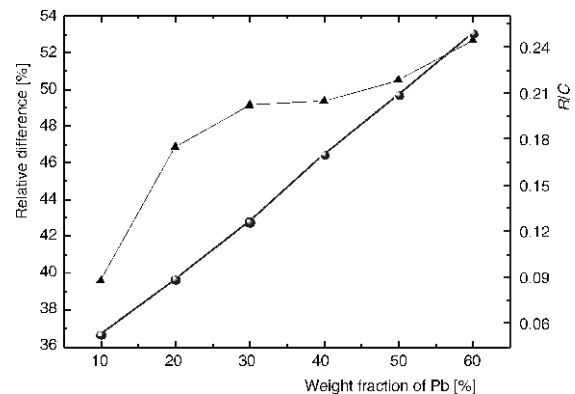


Figure 7. Relative difference (%) between Z_{eff} for total photon attenuation and photon scattering as a function of weight fraction (%) of Pb (black line on the left y axis) and ratios of Rayleigh to Compton cross sections as a function of weight fraction (%) of Pb (R/C) (blue line on the right y axis). Note an increase in both R/C ratios and the relative difference in Z_{eff} with an increase in weight fraction of Pb

ing of 59.54 keV γ -rays at an angle of 130° . Also, Z_{eff} values of these alloys were determined by an interpolation procedure and an excellent agreement observed between interpolation and fitting methods. The obtained Z_{eff} s for photon scattering were then compared to the Z_{eff} s for total photon attenuation, obtained using the Auto- Z_{eff} program. Significant variations were observed between the Z_{eff} s for scattering and total attenuation of gamma rays. The results led to a conclusion that Z_{eff} depends on the type of the interaction process, *i. e.* that scattering or attenuation, even for the same type of radiation, cannot be considered as a true constant.

AUTHORS' CONTRIBUTIONS

The experimental work was done by M. Buyukyildiz, theoretical values are to be attributed to M. Kurudirek. The motivation behind the research was provided by both M. Kurudirek and M. Buyukyildiz. M. Kurudirek carried out the analysis and discussion, the credit for the manuscript draft goes to M. Buyukyildiz.

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**ПРОРАЧУН ЕФЕКТИВНОГ АТОМСКОГ БРОЈА
 $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ ТРОЈНИХ ЛЕГУРА ЗА ФОТОНЕ**

У раду је израчунат ефективни атомски број Z_{eff} тројне легуре $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ за фотоне. Одређен је однос R/C Рејлијевог и Комптоновог расејања како би се израчунао ефективни атомски број тројне легуре $\text{Si}_x\text{Pb}_{0.7-x}(\text{Fe}_2\text{O}_3)_{0.3}$ са променљивим садржајем Si и Pb (10-60 %), за расејања гама фотона енергије 59.54 keV при углу од 130°. Теоријске вредности односа R/C елемената легуре приказане су као функција атомског броја и фитоване на полиномијални облик. Потом су експерименталне вредности R/C искоришћене како би се добиле Z_{eff} вредности помоћу ове полиномијалне једначине. Такође, вредности Z_{eff} ових легура одређене су по први пут интерполацијом R/C односа за материјале применом података о R/C односу суседних елемената у чијем су опсегу R/C вредности легура. Добијено је врло задовољавајуће поклапање резултата методом интерполације и применом фитовања једначина. Израчунате вредности Z_{eff} за расејање фотона упоређене су потом са вредностима за тоталну атенуацију фотона добијеним применом програма Ауто- Z_{eff} . Уочене су значајне варијације између Z_{eff} за расејање и тоталну атенуацију гама зрачења.

Кључне речи: ефективни атомски број, тројна легура, расејање, наелектрисана честица
