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MEASUREMENT OF INTERNAL CONVERSION COEFFICIENT Of 280kev γ – RAYS IN ^{203}Hg

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ABSTRACT

The measurement of the internal conversion coefficient of 280keV γ – ray in ^{203}HG have been investigated by means of calibrated 2″ x 2″ NaI(Tl)(scintillation detector which is sodium iodide activated with small amount of thallium) γ – rays spectrometer, using the standard γ – rays sources Co^{67} and Ba^{133} as shown in Table(1), and prepared a source of Hg^{203} from $Hg^{203}Cl_2$. It have been used some heavy element Au^{198} isotope Ti^{81}[3, 6, 9, 12,13, 15].
The total internal conversion coefficient of a γ – ray may be calculated by taking the ratio of the number of detected X – ray to the γ – ray, Equation (14).
In this workit have been discussed some important γ – ray interaction processes like photoelectric effect, Compton scattering and pair production etc. through which gamma ray interact with matter and get absorbed in it[1,2,16]. The measured value of internal conversion coefficient of 280KeV γ – ray in Hg^{203} at various source detector distances in centimeters (0.0, 3.2, and 4.2) which gives internal conversion coefficient (α) 0.230, 0.179 and 0.187 respectively.
The average internal conversion coefficient α, of 280 keV γ – ray in $Hg^{203}$is 0.2.
By comparingthe measurement results with the standard value, it had been found that the measured values of internal coefficient of 280 KeVγ – ray in ^{203}Hg was independent of source detector distance which was obvious and came out to be 0.20. Our experiment finding was in good agreement with the earlier reported value as 0.20.

KEYWORDS: ^{203}Hg – source, Nal(Tl) detector, X – ray, high voltage power supply, linear Amplifier, Single channel analyzer, Counter and Oscilloscope.

INTRODUCTION

Gamma ray were the electromagnetic radiation which originated due to nuclear transitions. Continuous X-ray were the result of the acceleration of the electrons or other charged particles and the characteristic X–ray arise due to the atomic transition of bound electrons between the K, L, M ------ shells in the atoms[2,3,4]. Energy associated with gamma rays ranges from thousands of eV to some millions of eV ($\approx 10 \times 10^3\ eV\ to\ 10 \times 10^3\ eV$), while the energy associated with the characteristic X – ray emitted due to the transition of electrons in the inner shells (K, L, M ------ etc.) of the atoms had energies up to few thousands of eV.
Photoelectric effect was the dominant process of γ–ray absorption in all the mediums specially in high Z material, in the energy range 50keV to 500keV.
The electromagnetic transitions may be detected in the two forms.Emission of γ – ray of energy $h\nu = E_2 - E_1$, where E_1 was the state to which the nucleus is dexciting, Internal conversion of γ – ray.
The conversion coefficients are strongly pairty dependent. The source of parity dependence arises from the structure of the electromagnetic potentials where for given L the electric multipolar have the orbital angular momentum $L \pm 1$ while for the magnetic multipolar the orbital angular momentum has single value L for a given L. Also the final electron states differ in the EL and ML conversion. For example from the K shell M1 transition leads to $s_{1/2}$ and $d_{3/2}$ final states, while E1 transition leads to the states $p_{1/2}$ and$p_{3/2}$. that last pair differed in parity from the first[1,2, 6, 8, 11, 16].

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THEORY

The quantum of energy of any of these radiation could be expressed as

$$E = h\nu \quad (1)$$

Where, ν was the frequency and *h* was the Planck's constant.

The entire photon energy *hν*was absorbed and an electron from one of the various shells K, L, M ------ etc[5,6,7,8]. was ejected from the atom with energy

$$T = h\nu - B_e \quad (2)$$

Where, B_e was the binding energy of the ejected electron.

By sing the laws of conservation of linear momentum and energy (in relativistic form) we get

$$\lambda` - \lambda = \left(\frac{h}{m_e c}\right)(1 - \cos\theta) \quad (3)$$

$$h\nu` = \frac{h\nu}{1 + \alpha(1 - \cos\theta)} \quad (4)$$

$$T = h\nu \frac{\alpha\,(1 - \cos\theta)}{1 + \alpha(1 - \cos\theta)} \quad (5)$$

$$\cot\phi = (1 + \alpha)\tan\theta/2 \quad (6)$$

Where, $\alpha = \left(\frac{h\nu}{m_e c^2}\right)$

At θ=90º if *hν*=10KeV then$\Delta h\nu = 0.2$KeV but at 1MeV, $\Delta h\nu = 0.66$MeV[1]. the calculation of the cross section for the Compton scattering was done by O. klein andY. Nishima, on the basis of quantum electrodynamics[18] and it was found that

$$\sigma_{cs} = Z \quad (7)$$

Where, Z was the atomic number of the absorber.

The threshold energy for the pair production was 1.01MeV and as the energy increases it becomes the dominant mode for the γ–ray to lose their energies. In this interaction the photon of energy *hν* was completely absorbed and in its place a positron–negatron pair appears, such that

$$h\nu = (T_- + m_e c^2) + (T_+ + m_e c^2) + E_{nucl} \quad (8)$$

where, T_- T_+ were the kinetic energy of negatron and positron, $m_e c^2$ was the rest of mass energy of electron or positron (= 0.51MeV) and E_{nucl} was the change in the kinetic energy of the nucleus in which Coulomb field the process of pair production take place.

The presence of this nucleus was necessary for momentum conservation. The cross section for pair production was found to be

$$\sigma_{pp} \propto Z^2\, in\, (\frac{2h\nu}{m_e c^2}) \quad (9)$$

According to Dirac's electron theory the total energy of electron can be both positive and negative.

$$E = \pm\sqrt{p^2c^2 + m_e^2 c^4} \quad (10)$$

The relative weight of the three main interaction mechanisms of photons with matter depended on the photon energy and the atomic number of the absorber. For a heavy element such as lead the photoelectric, Compton, pair production and total mass absorption coefficient as a function of photon energy *hν*[15,21]

These sharp peaks were supposed to exist due to the electron groups of certain definite energies. These electrons were called the internal conversion electrons or simply the conversion electrons.

In case (2) the surplus energy $(E_2 - E_1)$ of the nucleus may be directly transformed to an electron in one of the atomic shells of the same atom, and if the binding energy of the electron Be, was less than the energy $(E_2 - E_1)$ so transformed then that electron may be emitted from the atom. Thatemitted electron was called the internal conversion electron, the surplus nuclear energy would go more often to the K – electrons than to the electron in the outer L, M,…..etc[4,7]. shells. So the K – conversion process had usually the highest probability. The K.E. of the emitted conversion electron would be

$$E_e = h\nu - b_e \quad (11)$$

Blatt and Weisskopf gave and approximate formula for the internal conversion coefficient in the transitions for which the binding energy of the K – electrons was small compared with transition energy *hv* according to blatt and weisskopf, for the electric multipole transitions

$$a_k(EL) = z^3\left(\frac{e^2}{4\pi\varepsilon_0\hbar c}\right)^4 \frac{L}{L+1}\left(\frac{2m_ec^2}{hv}\right)^{L+5/2} \quad (12)$$

And for the magnetic multipole transitions

$$a_k(ML) = z^3\left(\frac{e^2}{4\pi\varepsilon_0\hbar c}\right)^4 \frac{L}{L+1}\left(\frac{2m_ec^2}{hv}\right)^{L+3/2} \quad (13)$$

But for very high energies ($hv >> m_ec^2$), σ_{pp} was independent of photon energy and depended only upon Z^2.

For a heavy element such as lead, the photoelectric, Compton, pair production and total mass absorption coefficient as a function of photon energy *hv*[1,2,13, 14]

If the detector makes a solid angle Ω on the source then the number of photons reaching to detector was only NΩ/ 4π.

To incorporate the absorption and scattering effects also, we introduced an attenuation factor 'f' such that

$f = \exp\{-(\mu_{air}\, t_{air} + \mu_{cap} t_{cap} + \mu_{ref} t_{ref})\}$

Where: t_{air} = distance traveled in air by γ – ray.

t_{cap} = distance traveled in aluminum cap by γ – ray.

t_{ref} = distance traveled in MgO reflector by γ – ray.

μ_{air} = absorption coefficient of γ – rays in air.

μ_{cap} = absorption coefficient of γ – rays in aluminum cap.

μ_{ref} = = absorption coefficient of γ – rays in MgO reflector.

Hence the number of photons reaching to the detector were NΩ/4π.[19,20,21]

EXPERIMENTAL METHOD:

A proper amount of $^{203}HgCl_2$ solution was dropped gently into the hole with a syringe and was allowed to dry under an electric lamp. This process was repeated again and again to get a reasonable amount of activity of the dried source. When the $^{203}HgCl_2$ solution was dried, we covered the hole with a single layer of cellophane tape.

We had used a scintillation detector supplied byNucleonix, which consist of a single cylindrical flat type crystal of sodium iodide activated with a small amount of thallium, this crystal of NaI(TI) was the size 2″x2″. NaI(TI)crystal was a hygroscopic material and absorbed moisture from the atmosphere and hence was hermetically sealed by an aluminum cap.

Thallium is added to NaI because the energy gap (gap between valence band and conduction band) of NaI was very high ($\approx 6\ to\ 8\ eV$) so the light emitted don't lie in the visible region.The presence of thallium in NaI shifted the energy spectrum to the visible region, for which(visible light) the crystal NaI was transparent.

γ–ray photons incident on the NaI(TI) crystal the those photons ejected photoelectrons, Compton recoil electrons or electron-positron pairs from the crystal. These electrons by their interaction with atoms or molecules of the crystal, generated a very large number of visible photons within a very short time, which appear as a sudden flash of light.

Since those electrons were moving towards the anode of photomultiplier tube so we got a large electric pulse at the anode. The amplitude of the pulse depended on the energy of the incident γ – ray. The pulses coming out of the photomultiplier tube were the fed to pre – amplifier. A block diagram for the γ – ray spectrometer is shown in Fig (1), is illustrated the devices which have been used in the experiment.

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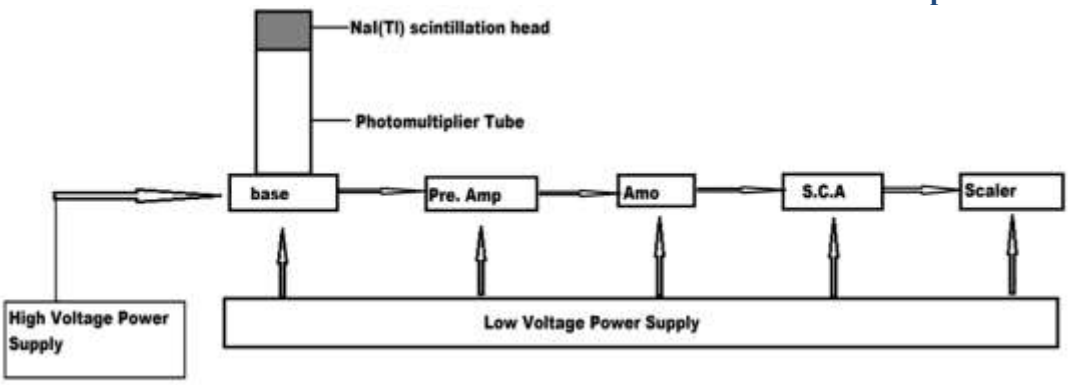

Fig* 1. *Block of the gamma ray spectrometer

The main purpose of that pre–amplifier was to preform impedance matching between the pre–amplifier input of low capacitance and its output of high capacitance. we had used a high voltage stabilized power supply of type HV502 made by Nucleonix, the output voltage of that power supply varied continuously from 0 to 2000Volts. The power supply was set at +595 Volts for operating the spectrometer. we had used a linear amplifier of the type LA520 made by Nucleonix, That linear amplifier the pulses to desired size and provided a voltage gain of the order of $10^3 (\approx 800)$. That linear amplifier also shaped the pulse using RC pulse shaping or delay line pulse shaping methods.
The single channel analyzer past only those pulses whose amplitude lies in between V(LLd) and V + ΔV (ULD). The level V was adjustable, so the entire spectrum of the pulse could be surveyed by increasing V step by step. A schematic diagram of NaI(Tl) detector and photomultiplier tube [20]
The counter of type CT542A made by Nucleonix had been used to counts the number of pulses that were fed to its input.
We had used the oscilloscope to ensure that the pulses coming from the linear amplifier had the desired size and the system was working properly[15, 21]. The amplification of the pulses was controlled by both the high voltage applied to NaI(Tl)detector and the gain setting of the linear amplifier.
The energy calibration of γ–ray spectrometer was very important for carrying out any γ–ray energy spectroscopic work. Using energy calibration curve the energy of unknown γ–ray corresponding to different baseline voltages can be determined. Which had calibrated the 2``x2``NaI(TI) γ–ray spectrometer using the standard γ– ray sources ^{57}CO and ^{133}Ba. As shown in ***table (1)***

Serial number	source	γ – ray energy (keV)	Baseline Voltage (Volt)
1	^{57}Co	122	3.1
2	^{133}Ba	320	7.8
3	^{133}Ba	356	9.1

DISCUSSION AND RESULT

The tables 2,3,and 4 give the observation that energy spectrum of ^{203}Hg at source detector distance 0.0cm , 3.2cm and 4.2cm respectively, for each distance we set the window of 0.1 volt and started taking counts by setting the baseline voltage at 0.1volt for the desired counting time 60 sec, 180 sec and180 sec. per baseline voltage, as shown in Table 2, 3 and 3 respectively.
To calculate the internal conversion coefficient we use the formula :

$$a = \frac{N_x}{N_\gamma} = \frac{S_x f_\gamma \Omega_\gamma \{1 - \exp(-\mu_\gamma x\rho)\}}{S_x f_\gamma \Omega_\gamma \{1 - \exp(-\mu_\gamma x\rho)\}\omega_k} \quad (14)$$

Since one millimeter thickness of NaI(Tl) absorbs 78 percent of X – ray and only 7 percent of the γ – ray from Hg^{203}. For 73 Kev X – ray, values of the required constants are:

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$$\mu_x(air) = 0.160\ cm^2/\ gm$$
$$\mu_x(air) = 0.160\ cm^2/\ gm$$
$$\mu_x(MgO) = 0.160\ cm^2/\ gm$$
$$\mu_x(NaI(Tl) = 4\ cm^2/\ gm$$
$$\omega_k = 0.95$$

For 280keV γ – ray, values of the required constants are:

$$\mu_\gamma(air) = 0.1094\ cm^2/\ gm$$
$$\mu_\gamma(Al) = 0.110\ cm^2/\ gm$$
$$\mu_\gamma(MgO) = 0.110\ cm^2/\ gm$$
$$\mu_\gamma(NaI(Tl) = 0.190\ cm^2/\ gm$$

Source detector distance = 0.0cm.
Setting of the spectrometer:
High voltage = 595volt
Attenuator = 2
Gain = 1 μs
Window opening = 0.1 volt
Counting time = 60 sec. per baseline voltage

Table 2: energy spectrum of ^{203}Hg at source detector distance 0.0cm.

LLD voltage	Observed counts	Background counts	Observed counts minus background count
0.1	74190	11505	62685
0.2	16130	2668	13462
0.3	2575	1338	1237
0.4	1520	755	765
0.5	1305	567	738
0.6	1218	523	695
0.7	1348	447	901
0.8	1202	354	848
0.9	1238	305	933
1.0	1464	254	1210
1.1	1503	289	1214
1.2	1364	366	998
1.3	1361	369	992
1.4	1538	435	1103
1.5	1775	508	1267
1.6	2150	521	1629
1.7	3463	575	2888
1.8	5644	563	5081
1.9	6207	702	5505
2.0	4508	704	3804
2.1	3165	720	2445
2.2	2557	661	1896
2.3	1846	638	1208
2.4	1438	654	784
2.5	1313	648	665
2.6	1422	601	821
2.7	1314	604	710
2.8	1373	611	762
2.9	1370	580	790
3.0	1440	551	889

3.1	1487	552	935
3.2	1597	527	1070
3.3	1740	553	1187
3.4	1873	487	1386
3.5	2051	471	1580
3.6	2062	466	1596
3.7	1971	442	1529
3.8	1728	402	1326
3.9	1528	420	1108
4.0	1416	408	1008
4.1	1336	370	966
4.2	1164	342	822
4.3	1117	321	796
4.4	1055	313	742
4.5	966	308	658
4.6	995	352	643
4.7	941	322	619
4.8	868	270	598
4.9	798	254	544
5.0	790	250	540
5.1	768	251	517
5.2	776	245	531
5.3	768	221	547
5.4	720	235	485
5.5	722	229	493
5.6	731	241	490
5.7	742	223	519
5.8	787	204	583
5.9	794	189	605
6.0	771	177	594
6.1	811	186	625
6.2	820	172	648
6.3	957	161	796
6.4	1644	183	1461
6.5	2367	173	2194
6.6	4335	158	4177
6.7	7290	128	7162
6.8	10123	138	9985
6.9	12253	135	12118
7.0	13093	125	12968
7.1	12662	118	12544
7.2	11054	130	10924
7.3	8360	125	8235
7.4	5728	116	5612
7.5	3220	111	3109
7.6	1667	91	1575
7.7	780	86	694
7.8	357	87	270

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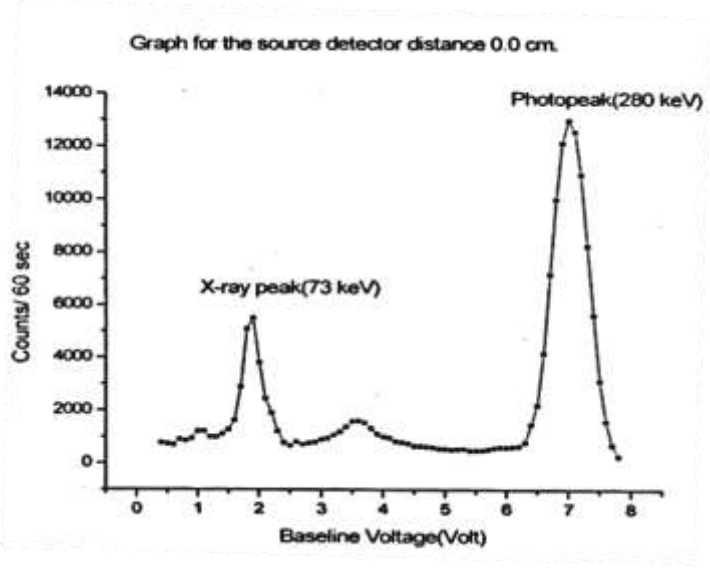

Fig. 2.Energy spectrum of ^{203}Hg at source detector distance 0.0cm

Fig (2): shows that the increasing of the baseline voltage in step of 0.1 volt up to 7.8 volt was plotted against the desired counting time 60sec, which express the energy spectra of HG^{203} source detector at distance 0.0cm that gives photo peaks recorded at 280Kev, and the X-ray peaks recorded at 73kev, the area under the photo peak of a particular energy E in an energy spectrum represents the total number of photons of energy E detector by detector.

Source detector distance = 3.2cm.

Setting of the spectrometer:
High voltage = 595volt
Attenuator = 2
Gain = 1
Fine gain = three rounds less then maximum
Time constant = 1 μs
Polarity = positive
Window opening = 0.1 volt
Counting time = 180 sec.per baseline voltage

Table 3. energy spectrum of ^{203}Hg at source detector distance 3.2

LLD voltage	Observed counts	Background counts	Observed counts minus background count
0.1	69066	37812	31254
o.2	13445	8490	4955
0.3	3330	3212	118
0.4	2023	1828	195
0.5	1675	1275	400
0.6	1386	986	400
0.7	1327	838	489
0.8	1377	804	573
0.9	1238	685	553
1.0	1351	652	699
1.1	1456	744	712
1.2	1372	833	539
1.3	1550	978	572

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1.4	2018	1175	843
1.5	2591	1337	1254
1.6	2934	1380	1554
1.7	3769	1602	2167
1.8	4331	1760	2571
1.9	4852	1851	3001
2.0	4115	1841	2274
2.1	3433	1894	1539
2.2	3033	1811	1222
2.3	2648	1852	796
2.4	2344	1867	477
2.5	2272	1738	434
2.6	2236	1757	479
2.7	2190	1693	497
2.8	2038	1540	498
2.9	2191	1596	595
3.0	2167	1537	580
3.1	2158	1469	689
3.2	2152	1423	729
3.3	2155	1419	736
3.4	2293	1355	958
3.5	2237	1311	926
3.6	2241	1178	1063
3.7	2257	1210	1047
3.8	2106	1102	1004
3.9	1955	1071	884
4.0	1865	1078	787
4.1	1864	1008	856
4.2	1716	931	785
4.3	1672	956	716
4.4	1581	874	707
4.5	1544	855	689
4.6	1422	861	561
4.7	1415	787	628
4.8	1336	791	545
4.9	1232	780	452
5.0	1248	760	488
5.1	112	682	443
5.2	1142	673	469
5.3	1091	672	419
5.4	1005	642	353
5.5	1003	626	377
5.6	1011	601	410
5.7	1008	611	387
5.8	976	586	390
5.9	974	566	408
6.0	944	571	373
6.1	899	534	365
6.2	891	480	411

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6.3	977	462	515
6.4	1254	426	828
6.5	2046	400	1646
6.6	3384	390	2994
6.7	4979	330	4649
6.8	6591	335	6256
6.9	7540	360	7180
7.0	7787	338	7449
7.1	7175	309	6866
7.2	5829	358	5471
7.3	4296	330	3966
7.4	2720	286	2434
7.5	1636	310	1326
7.6	874	291	583
7.7	493	286	207
7.8	372	242	130

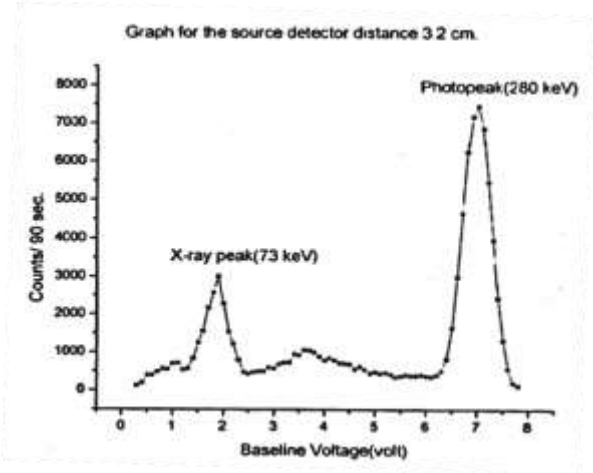

Fig. 3.Energy spectrum of ^{203}Hg at source detector distance 3.2cm

Fig (3): shows that the increasing of the baseline voltage in step of 0.1 volt up to 7.8 volt was plotted against the desired counting time 90sec, which express the energy spectra of HG^{203} source detector at distance 3.2 cm that gives photo peaks recorded at 280Kev, and the X-ray peaks recorded at 73kev, the area under the photo peak of a particular energy E in an energy spectrum represents the total number of photons of energy E detector by detector.

Source detector distance = 4.2cm
Sitting of the spectrometer:
High voltage = 595volt
Attenuator = 2
Gain = 1
Fine gain = three rounds less then maximum
Time constant = 1 μs
Polarity = positive
Window opening = 0.1 volt
Counting time = 180 sec.per baseline voltage

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Table 4. energy spectrum of ^{203}Hg at source detector distance 4.2

LLD voltage	Observed counts	Background counts	Observed counts minus background count
0.1	3644	3291	453
o.2	2283	1939	344
0.3	1638	1314	324
0.4	1301	1015	286
0.5	1151	911	240
0.6	1222	928	294
0.7	1087	762	325
0.8	993	631	362
0.9	1038	696	342
1.0	1129	742	387
1.1	1284	825	459
1.2	1342	1031	311
1.3	1618	1226	392
1.4	1911	1359	552
1.5	2176	1476	700
1.6	2700	1541	1259
1.7	3516	1752	1764
1.8	3725	1892	1823
1.9	3223	1876	1347
2.0	2829	1918	911
2.1	2544	1868	676
2.2	2315	1842	473
2.3	2102	1831	271
2.4	2168	1889	279
2.5	2006	1735	271
2.6	2017	1778	239
2.7	2001	1712	289
2.8	1881	1690	191
2.9	1969	1600	369
3.0	1882	1526	356
3.1	1775	1382	393
3.2	1709	1349	360
3.3	1764	1316	448
3.4	1757	1274	483
3.5	1659	1170	489
3.6	1692	1199	493
3.7	1633	1133	500
3.8	1641	1092	459
3.9	1516	1037	479
4.0	1518	1011	507
4.1	1416	971	445
4.2	1364	931	433
4.3	1324	924	400
4.4	1274	840	434
4.5	1323	869	454
4.6	1246	787	459

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4.7	1225	835	390
4.8	1149	803	346
4.9	1118	742	376
5.0	1076	685	391
5.1	1040	665	375
5.2	1030	689	341
5.3	948	685	263
5.4	904	682	222
5.5	903	587	222
5.6	828	580	248
5.7	848	569	279
5.8	841	607	234
5.9	840	530	310
6.0	871	544	327
6.1	795	493	302
6.2	795	511	284
6.3	709	423	286
6.4	958	445	513
6.5	1429	405	1024
6.6	2349	373	1976
6.7	3549	388	3161
6.8	4095	387	3708
6.9	4493	383	4110
7.0	4634	367	4267
7.1	4092	330	3762
7.2	3298	314	2984
7.3	2180	308	1872
7.4	1532	322	1210
7.5	871	257	614
7.6	562	282	280
7.7	401	267	134
7.8	298	251	47
7.9	263	238	25

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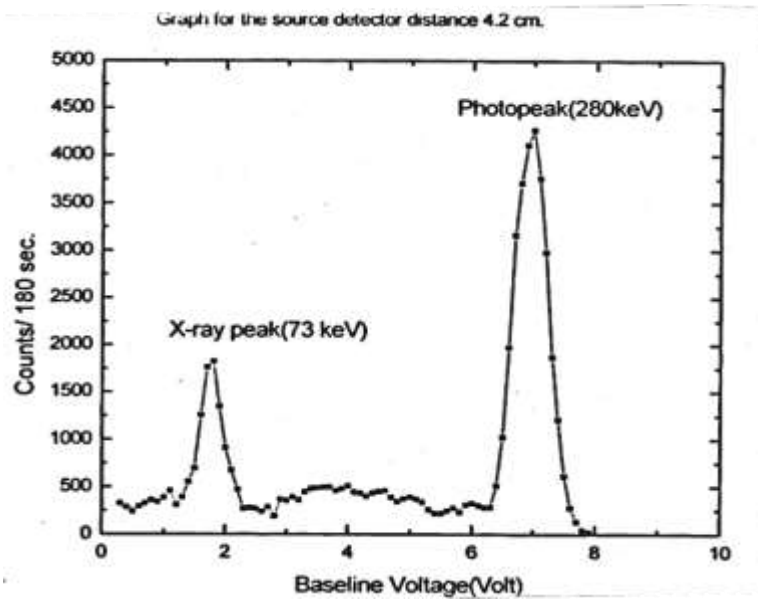

Fig. 4.energy spectrum of ^{203} Hg at source detector distance 4.2

Fig (4): shows that the increasing of the baseline voltage in step of 0.1 volt up to 7.8 volt was plotted against the desired counting time 180sec, which express the energy spectra of HG^{203} source detector at distance 4.2cm that gives photo peaks recorded at 280Kev, and the X-ray peaks recorded at 73kev, the area under the photo peak of a particular energy E in an energy spectrum represents the total number of photons of energy E detector by detector.

Results and Calculations

For the first set: since source detector distance = 0.0cm.

So $t_{air} = 0.0cm = 0.0 * 1.29 * 10^{-3} = 0.0mg/cm^2$

Given $t_{cap(Al)} = 135\ mg/cm^2$

$t_{ref(MgO)} = 135\ mg/cm^2$

So for X-ray

$f_x = \exp\{-(\mu_{air}\, t_{air} + \mu_{cap} t_{cap} + \mu_{ref} t_{ref})\}$

$= \exp\{-(0.160 * 0.0 + 1.098 * 10^{-3} * 135 + 0.198 * 10^{-3} * 350)\}$

= 0.90844

So the γ rays

$f_\gamma = \exp\{-(\mu_{air}\, t_{air} + \mu_{cap} t_{cap} + \mu_{ref} t_{ref})\}$

$= \exp\{-(0.0 + 0.110 * 10^{-3} * 135 + 0.110 * 10^{-3} * 350)\}$

= 0.90844

Thickness of the Nal (Tl) crystal = 2.54* 2 cm = 5.08

So for the X-ray :

$\exp\{-(\mu_x X\rho)\} = \exp\{-(4 * 5.08 * 3.67)\}$

$= 4.099 * 10^{-33} \approx 0.0$

So the γ rays

$\exp\{-(\mu_\gamma X\rho)\} = \exp\{-(0.190 * 5.08 * 3.67)\}$

= 0.02895

For K – X ray in ^{203}Hg $\omega_k = 0.95$

Area of X ray peak = S_x= 425 squares

Area of γ ray peak = S_γ = 1970 squares

So, the internal conversion coefficient :

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$$a = \frac{S_x f_\gamma \Omega_\gamma \{1 - \exp(-\mu_\gamma x\rho)\}}{S_x f_\gamma \Omega_\gamma \{1 - \exp(-\mu_\gamma x\rho)\}\omega_k}$$

$$\frac{425 * 0.94805 * 2 * 3.14 * (1 - 0.02895)}{1970 * 0.094805 * 3.14 * (1 - 0) * 0.95}$$

$= 0.230$

For the second set: since source detector distance = 3.2cm.

So $t_{air} = 0.0cm = 0.0 * 1.29 * 10^{-3} = 0.0mg/cm^2$

Given $t_{cap(Al)} = 135\ mg/cm^2$

$t_{ref(MgO)} = 135\ mg/cm^2$

So for X-ray

$f_x = \exp\{-(\mu_{air}\, t_{air} + \mu_{cap} t_{cap} + \mu_{ref} t_{ref})\}$

$= 0.90784$

So the γ rays

$f_\gamma = \exp\{-(\mu_{air}\, t_{air} + \mu_{cap} t_{cap} + \mu_{ref} t_{ref})\}$

$= 0.9472$

Thickness of the Nal (Tl) crystal = 2.54* 2 cm = 5.08

So for the X-ray :$\exp\{-(\mu_x X\rho)\} = \exp\{-(4 * 5.08 * 3.67)\}$

$= 4.099 * 10^{-33}$

≈ 0.0

So the γ rays

$\exp\{-(\mu_\gamma X\rho)\} = \exp\{-(0.190 * 5.08 * 3.67)\}$

$= 0.02895$

For K – X ray in ^{203}Hg $\omega_k = 0.95$

Area of X ray peak = S_x= 635 squares

Area of γ ray peak = S_γ = 2193 squares

So, the internal conversion coefficient :

$a = \frac{S_x f_\gamma \Omega_\gamma \{1-\exp(-\mu_\gamma x\rho)\}}{S_x f_\gamma \Omega_\gamma \{1-\exp(-\mu_\gamma x\rho)\}\omega_k} = 0.179$

For the third set: since source detector distance = 4.2cm.

So $t_{air} = 4.2cm = 4.2 * 1.29 *$

Given $t_{cap(Al)} = 135\ mg/cm^2$

$t_{ref(MgO)} = 135\ mg/cm^2$

So for X-ray

$f_x = \exp\{-(\mu_{air}\, t_{air} + \mu_{cap} t_{cap} + \mu_{ref} t_{ref})\}$

$= 0.90765$

So the γ rays

$f_\gamma = \exp\{-(\mu_{air}\, t_{air} + \mu_{cap} t_{cap} + \mu_{ref} t_{ref})\}$

$= 0.94749$

Thickness of the Nal (Tl) crystal = 2.54* 2 cm = 5.08

So for the X-ray :

$\exp\{-(\mu_x X\rho)\} = \exp\{-(4 * 5.08 * 3.67)\}$

$= 4.099 * 10^{-33} \approx 0.0$

So the γ rays

$\exp\{-(\mu_\gamma X\rho)\} = \exp\{-(0.190 * 5.08 * 3.67)\}$

$= 0.02895$

For K – X ray in ^{203}Hg $\omega_k = 0.95$

Area of X ray peak = S_x= 701 squares

Area of γ ray peak = S_γ = 2613 squares

So, the internal conversion coefficient :
a = 0.187

CONCLUSIONS

The value of the internal conversion coefficient of 280KeV γ – ray in ^{203}Hg for all the three different observation sets were listed in table.

Table 5: measured value of internal conversion coefficient of 280KeV γ – ray in ^{203}Hg at various source detector distance

Source detector distance (cm)	0.0	3.2	4.2
Internal conversion coefficient	0.230	0.179	0.187

Average internal conversion coefficient α, of 280 KeVγ – ray in ^{203}Hg = 0.2.
In that experiment three energy calibrated γ – X spectra of ^{203}Hg have been recorded, by placing the source at three different distance: 0.0cm, 3.2cm and 4.2cm. using NaI(TI) detector. With the help of those spectra the internal conversion coefficient of 280KeV γ – ray in ^{203}Hg had been calculated by using the following formula :

$$a = \frac{N_x}{N_\gamma} = \frac{S_x f_\gamma \Omega_\gamma \{1 - \exp(-\mu_\gamma x\rho)\}}{S_x f_\gamma \Omega_\gamma \{1 - \exp(-\mu_\gamma x\rho)\}\omega_k}$$

All the possible correction including the solid angle effected had been incorporated. It had been found that the measured values of internal coefficient of 280 KeVγ – ray in ^{203}Hg was independent of source detector distance which was obvious and came out to be 0.20. Our experiment finding was in good agreement with the earlier reported value as 0.20.

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