New Gamma Transitions in ^{193}Ir From the Beta Decay of ^{193}Os

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The population and the mode of decay of the low-lying excited levels of ^{193}Ir have been investigated by single and $\gamma\gamma$ coincidence spectroscopy using ^{192}Os enriched to 99% and several HPGe detectors. From singles spectra analysis the energies of 71 gamma rays have been determined with a better overall precision than previously, 17 of them for the first time. The energies at $1043.244(15)$ and $1316.628(18)keV$, observed for the first time in this work, as well as some preliminary coincidence relationships, suggest that the end point energy $Q_{\beta max}$ (≈1.14MeV) must be further investigated.

1 Introduction

According to the studies performed by Avida, *et al* (1968)[1], Price, R. H. and Johns, M. W. (1972)[2] and more recently by McGowan, F. K. *et al* (1987)[3], the beta decay scheme of ^{193}Os ($T_{1/2} = 30.6$h) is yet very incomplete. Besides, considering that this nucleus occupies a central position in the complex transitional region between the deformed Rare-Earth nuclei and the spherical nuclei near Pb isotopes the investigation of this beta decay gives the opportunity to verify if the deformation affects the low-lying states of ^{193}Os in an attempt to better understand the trends in its nuclear structure.

In this work, we discuss the results obtained in measurements involving single spectroscopy performed using samples of metallic highly enriched ^{192}Os and high energy resolution (FWHM≈ $1.8keV$) HPGe spectrometers. In addition, preliminary $\gamma\gamma$ coincidence results are used to analyze some new high-energy transitions found in the spectroscopy.

2 Experimental Procedure

Samples for the spectroscopy were obtained by the irradiation of 5mg of enriched Osmium (99% ^{192}Os) for a period of 10 minutes in the IEA-R1 reactor at IPEN-So Paulo, with a thermal neutron flux of $5x10^{12}n.cm^{-2}.s^{-1}$.

For the $\gamma\gamma$ coincidence studies, the ^{192}Os samples were irradiated either for 20 minutes under a $5x10^{12}n.cm^{2}.s^{-1}$ in the reactor's pneumatic irradiation channels or for 5 minutes under a thermal flux around $2x10^{13}n.cm^{2}.s^{-1}$ in the irradiation positions closer to the reactor core.

The singles spectra were taken using a 198cm^3 HPGe detector (FWHM= $1.89keV$ at $1.32MeV$) and a ORTEC 671 amplifier in pile-up rejection mode, connected to a ORTEC 919 multichannel analyzer working at 4096 channels resolution.

The energy calibration of the γ-transitions spectra was taken with standard sources of ^{109}Cd, ^{133}Ba, ^{137}Cs and ^{152}Eu, and the relative efficiency calibration of the detector was made with standard sources of ^{133}Ba and ^{152}Eu. The direct gamma-ray spectrum from about $50keV$ to $1.4MeV$ was recorded over more than 890 hours of live counting. Peak areas were evaluated using the IDEFix computer code[4]. Also, in order to positively identify the origin of the γ-rays, spectra were accumulated through two successive half-lives and the counts in each half-life were confronted.

The coincidence measurements were performed using 4 high-resolution HPGe dectetors. The multiparametric data acquisition system used, installed in the Acelerador Linear Laboratory of the Physics Institude (LAL/IFUSP) registers events in which the difference between the start and stop time signals doesn't exceed 200μs. The preliminary coincidence analysis was performed by gating the coincidence matrix in the newly-found high energy peaks using the BIDIM[5] computer code and analyzing the coincident spectra using the IDEFix[4] computer code.

3 Discussion

According to our measurements seventeen γ-transitions with energies 61.0, 70.8, 128.8, 153.2, 198.5, 296.5, 298.9, 342.8, 344.7, 385.7, 394.3, 517.2, 615.2, 616.3, 618.5, 645.4, 660.4, 664.4, 697.7, 706.2, 827.1, 846.1, 1043.2 and $1316.6keV$ were observed for the first time but no evidence was found for the doublet at $333.3keV$ and $337.7keV$ observed only by Price and Johns[2]. Besides, the energy at $517keV$, reported solely by Avida et. al.[1], was not observed in our study although the present experiment has achieved better observation limits. Our results are summarized and compared to the values compiled by Firestone[6] in Table 1.

TABLE 1. Energy (E) and Intensity (I_γ) of the gamma rays from the beta decay of ^{193}Os ($T_{1/2} = 30,6$h) compared to the compilation performed by Firestone[6]. The intensities are calculated relative to that of the $459.9953keV$ transition.

E_e(keV)	E_r(keV)[6]	$I_{\gamma,e}$	$I_{\gamma,r}$[6]	E_e(keV)	E_r(keV)[6]	$I_{\gamma,e}$	$I_{\gamma,r}$[6]
	41.18(7)[a]			386.9235(16)	387.48(4)	3.66(14)	31.9(16)
61.0298(11)		6.1(3)		394.30(7)		0.044(7)	
62.6376(8)[x]		43(2)		413.05(3)	413.8(2)	0.095(9)	0.12(4)
64.3026(8)[x]	65.87(6)	60(3)	0.06		418[a]		0.18(4)
70.7901(11)		7.4(3)		417.834(3)	418.35(8)	1.35(6)	1.38(14)
72.6158(8)[x]	73.039(12)	73(3)	82(12)	419.7113(14)	420.3(5)	4.05(16)	4.2(3)
75.216(9)[x]		2.10(10)		440.3471(17)	440.95(5)	2.27(9)	2.32(16)
	80.22(2)[b]			459.8973(13)	460.49(3)	100(4)	100(5)
96.295(7)	96.82(3)	1.72(10)	2.5(2)	483.7100(15)	484.25(5)	4.11(18)	4.3(3)
98.36(3)	98.7(8)	0.45(3)	0.42(6)		486.11(15)		0.29(14)
106.4549(9)	107.01(12)	9.5(6)	16.1(8)		512.3(3)		0.04(2)
128.7765(14)		2.41(9)		514.372(15)	514.95(1)	0.34(2)	0.28(5)
	136[a]				516.3(4)		0.06(3)
138.3634(9)	138.92(3)	79(3)	108(5)	517.24(3)	517 [c]	0.047(5)	
141.593(3)	142.13(8)	1.17(5)	1.9(2)	524.571(6)	524.98(8)	0.432(18)	0.40(4)
153.19(3)	153[c]	0.160(8)		531.496(2)	532.02(5)	2.01(11)	2.10(15)
154.302(11)	154.74(3)	0.438(17)	0.76(11)	555.412(11)	556[a]	1.74(7)	0.08(2)
179.5006(12)	180.03(3)	3.93(14)	4.6(5)	556.7691(16)	557.36(8)	36.1(14)	33(3)
	181[a]		0.008	558.6415(16)	559.26(8)	13.1(5)	12.3(12)
181.2133(12)	181.81(3)	4.12(15)	4.9(5)		560[a]		0.07(2)
196.88(2)	197.4(2)	0.18(3)	0.12(4)	572.593(7)	573.33(1)	0.47(5)	0.49(5)
198.52(7)		0.12(4)		597.57(11)	598.1(3)	0.015(4)	0.017(8)
200.90(3)	201.5(3)	0.19(4)	0.07(4)	615.17(18)		0.059(10)	
	218.2(2)			616.30(11)		0.137(14)	
	219[a]		0.22(5)	618.498(11)		0.461(20)	
218.5609(10)	219.13(5)	5.7(2)	7.0(5)	638.504(15)	639.09(1)	0.264(14)	0.19(3)
234.027(3)	234.58(6)	1.00(5)	1.30(17)	645.436(11)		0.28(6)	
251.0558(12)	251.62(4)	5.4(2)	5.5(4)	660.43(11)		0.22(10)	
279.8511(12)	280.44(23)	34.3(13)	31.5(16)	664.36(11)		0.50(2)	
288.1782(13)	288.79(5)	3.35(13)	3.6(3)	667.68(11)	668.3(3)	0.23(10)	0.019(9)
	290[c]			694.49(4)	695.12(1)	0.077(13)	0.072(14)
296.518(4)		1.84(7)		697.725(18)		0.286(24)	
298.057(3)	298.83(5)	5.5(2)	4.7(4)	706.23(11)		0.026(11)	
298.897(5)		2.20(9)		709.43(7)	709.93(15)	0.120(13)	0.052(13)
	317[c]			711.521(15)	712.1(1)	0.55(4)	0.39(6)
320.9758(11)	321.59(4)	30.4(12)	32.3(16)	734.80(15)	735.3(3)	0.024(12)	0.027(7)
	333.3(3)[d]		0.07(4)	775.834(5)	775.9(3)	0.92(4)	0.010(5)
	337.7(5)[d]		0.03(2)		778.48(15)		0.042(9)
342.79(4)		0.101(14)			784.2(2)		0.017(4)
344.67(4)		0.116(14)			800.9(3)[d]		0.008(4)
350.982(3)	350.2(2)	3.71(15)	0.18(6)	827.138(18)		0.163(11)	
357.082(11)	357.7	0.20(2)	0.25(8)	846.065(5)		1.87(9)	
361.2180(12)	361.81(5)	7.8(3)	7.5(6)	848.50(5)	848.85(15)	0.153(2)	0.11(2)
376.6934(22)	377.31(7)	1.89(8)	1.8(2)	873.604(8)	874.36(15)	0.53(3)	0.48(7)
	378[a]		0.041(10)	891.42(5)	891.26(15)	0.24(3)	0.072(11)
378.51(2)	379.04(15)	0.294(13)	0.35(9)	1043.244(15)		0.299(15)	
385.72(3)		0.152(8)		1316.628 (18)		0.316 (19)	

[x] - Known X-Rays for ^{193}Os;
[a] - Not directly observed: deduced from $\gamma\gamma$ measurements from Price and Johns[2]
[b] - This transition depopulates the isomer at $80.19keV$;
[c] - Extracted from Avida et al[1], where no experimental uncertainty was reported;
[d] - Observed only in γ spectroscopy measurements by Price and Johns[2].

Particularly the new gamma transitions at 1043.244 and $1316.628keV$ can only belong to this beta decay if the end point energy is higher than the established. Also, the preliminary results of our $\gamma\gamma$ coincidence study show both these energies, and also suggests that the photopeaks at 555.412 and $775.834keV$ are in coincidence with each other and with the $1316.628keV$ one, thus suggesting that either the maximum beta energy is underestimated by a large factor or that some other radionuclide has been produced in our sample; on the other hand, no nuclide that might be produced in the vicinity of ^{193}Os has known decays at all these three energies. Fig. 1 shows the coincidence spectra for these two photopeaks taken for the pair of detectors at 90^o of each other.

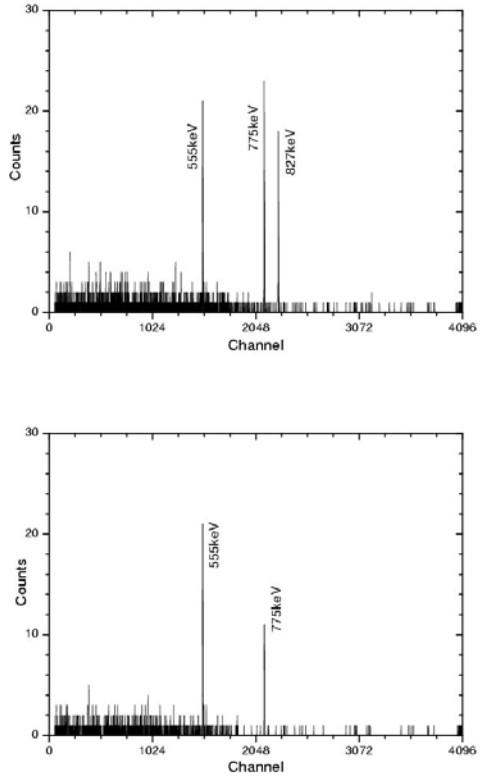

Figure 1. Coincidence spectra for the newly found decays at 1043 (left) and $1317keV$.

Considering that the origin of these γ-rays was verified through two successive half-lives, these results suggest the necessity to perform beta spectroscopy measurements in the excited states of ^{193}Ir populated by the presently studied beta decay.

4 Conclusions

From singles spectra analysis seventeen new transitions are proposed but several transitions earlier attributed to this beta decay are not confirmed. In addition to this, some $\gamma\gamma$ coincidence relationships, involving γ rays with energy higher than or close to the end point energy ($\approx 1.14MeV$), suggests that $Q_{\beta max}$ must be investigated.

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