

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 $Q_{\beta\text{max}}$ ($\approx 1.14\text{MeV}$) 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 ($T_{1/2} = 30.6\text{h}$) 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 $\approx 1.8\text{keV}$) 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 $5 \times 10^{12} \text{n.cm}^{-2}.\text{s}^{-1}$.

For the $\gamma\gamma$ coincidence studies, the ^{192}Os samples were irradiated either for 20 minutes under a $5 \times 10^{12} \text{n.cm}^{-2}.\text{s}^{-1}$ in the reactor's pneumatic irradiation channels or for 5 minutes under a thermal flux around $2 \times 10^{13} \text{n.cm}^{-2}.\text{s}^{-1}$ 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 detectors. The multiparametric data acquisition system used, installed in the Acelerador Linear Laboratory of the Physics Institute (LAL/IFUSP) registers events in which the difference between the start and stop time signals doesn't exceed $200\mu\text{s}$. 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 ($T_{1/2} = 30, 6\text{h}$) 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]
61.0298(11)	41.18(7) ^a	6.1(3)		386.9235(16)	387.48(4)	3.66(14)	31.9(16)
62.6376(8) ^x		43(2)		394.30(7)		0.044(7)	
64.3026(8) ^x	65.87(6)	60(3)	0.06	413.05(3)	413.8(2)	0.095(9)	0.12(4)
70.7901(11)		7.4(3)		417.834(3)	418.35(8)	1.35(6)	0.18(4)
72.6158(8) ^x	73.039(12)	73(3)	82(12)	419.7113(14)	420.3(5)	4.05(16)	1.38(14)
75.216(9) ^x		2.10(10)		440.3471(17)	440.95(5)	2.27(9)	4.2(3)
	80.22(2) ^b			459.8973(13)	460.49(3)	100(4)	2.32(16)
96.295(7)	96.82(3)	1.72(10)	2.5(2)	483.7100(15)	484.25(5)	4.11(18)	100(5)
98.36(3)	98.7(8)	0.45(3)	0.42(6)		486.11(15)		4.3(3)
106.4549(9)	107.01(12)	9.5(6)	16.1(8)		512.3(3)		0.29(14)
128.7765(14)		2.41(9)		514.372(15)	514.95(1)	0.34(2)	0.04(2)
	136 ^a				516.3(4)		0.28(5)
138.3634(9)	138.92(3)	79(3)	108(5)	517.24(3)	517 ^c	0.047(5)	0.06(3)
141.593(3)	142.13(8)	1.17(5)	1.9(2)	524.571(6)	524.98(8)	0.432(18)	
153.19(3)	153 ^c	0.160(8)		531.496(2)	532.02(5)	2.01(11)	0.40(4)
154.302(11)	154.74(3)	0.438(17)	0.76(11)	555.412(11)	556 ^a	1.74(7)	2.10(15)
179.5006(12)	180.03(3)	3.93(14)	4.6(5)	556.7691(16)	557.36(8)	36.1(14)	0.08(2)
	181 ^a		0.008	558.6415(16)	559.26(8)	13.1(5)	33(3)
181.2133(12)	181.81(3)	4.12(15)	4.9(5)		560 ^a		12.3(12)
196.88(2)	197.4(2)	0.18(3)	0.12(4)	572.593(7)	573.33(1)	0.47(5)	0.07(2)
198.52(7)		0.12(4)		597.57(11)	598.1(3)	0.015(4)	0.49(5)
200.90(3)	201.5(3)	0.19(4)	0.07(4)	615.17(18)		0.059(10)	0.017(8)
	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° of each other.

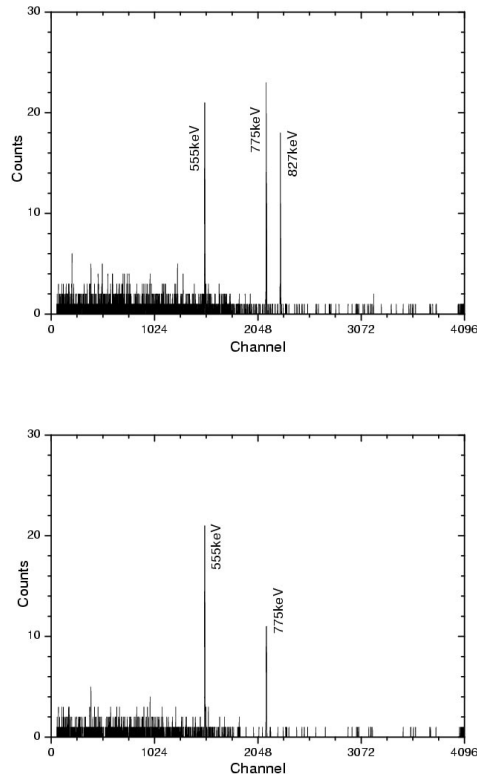


Figure 1. Coincidence spectra for the newly found decays at 1043 (left) and 1317 keV.

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 ($\approx 1.14\text{MeV}$), suggests that $Q_{\beta_{max}}$ must be investigated.

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