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INVESTIGATION OF THE NEW 960KEV LEVEL IN ^{193}IR USING A MULTIPARAMETRIC DETECTION SYSTEM

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ABSTRACT

In this work the level at E=959.89keV, recently identified in the β^- decay of ^{193}Os to ^{193}Ir, is investigated using data acquired with a multiparametric detection system composed of four Germanium detectors allowing for both γ–γ coincidence and directional correlation analyses. A review on the literature shows that the coincidence that defines this level had already been seen in a previous work, but discarded as a summing effect; the coincidence analysis, though, positively confirms this level. From the beta decay selection rules, it is possible to assign a definite positive parity to this state, and the angular correlation study indicates that its spin must be either 1/2 or 3/2.

1. INTRODUCTION

The nucleus ^{193}Ir occupies a very interesting place in the nuclide table, between the prolate-deformed ^{192}Os and the oblate ^{194}Pt nuclei [1]; as for the ^{193}Ir nucleus, there are studies describing it both as a triaxial rotor [1-4] and as a prolate rotor [5].

In a recent work [6] we have discussed the results of a γ–γ coincidence study on the β^- decay of ^{193}Os to ^{193}Ir, where several new transitions were found and four new energy levels identified; one of these, at E=959.89(18)keV, was rather intriguing due to the relatively high intensity (I_{rel}=0.083(7)) of the γ transition that depopulates it, so it was decided to further investigate this level; the 960keV level, together with a simplified decay scheme where only the levels and transitions that are relevant to the present discussion, can be seen in Fig. 1.

In fact, a review in the previous experimental works on this decays shows that the coincidence that defines this new level, between the well-established 298.8keV γ transition and a transition with 362keV had already been seen by Price & Johns [7], but discarded as an accidental coincidence between the 298.8keV transition and the very strong 361.8keV transition that depopulates the 361.8keV level; on the opposite coincidence gate, on the 361.8keV transition, a peak at 299keV was discarded as a "gate summing", i.e., as a possible summing effect between the 99keV and 197keV transitions.

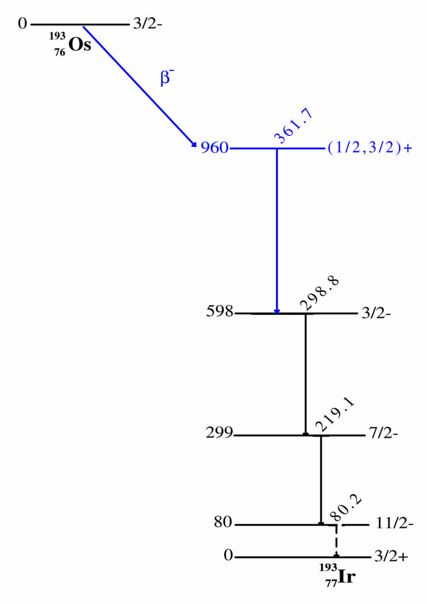

Figure 1. Simplified b- decay scheme of ^{193}Os, where only the levels and transitions in ^{193}Ir that are relevant to the present discussion are shown.

2. EXPERIMENTAL PROCEDURE

2.1. Data Acquisition

The present experiment was performed using the planar multidetector array system assembled at the Laboratório do Acelerador Linear (LAL), in the Physics Institute of the São Paulo University [8]. For this experiment, four HPGe detectors, with volumes ranging from 50 to 120 cm^3, were used in coincidence mode; the detectors were placed around the sample as shown in Fig. 2a; the angles between the detector pairs were chosen to allow for four independent angles for the angular correlation study (two pairs at 90^o, two at 120^o, one at 150^o and one at 180^o).

The coincidence electronics, schematically shown in Fig. 2b, checks for a coincidence between two or more detectors within 200ns and, for each valid event, stores both time and energy information for each detector involved.

The samples were produced by irradiating 5mg of 99% enriched ^{192}Os for 5 minutes in the IEA-R1 reactor, under a neutron flux of about 10^{12}cm^{-2}.s^{-1}. Two sources were produced every week, and this procedure was repeated for two months, resulting in approximately 1200h of counting time.

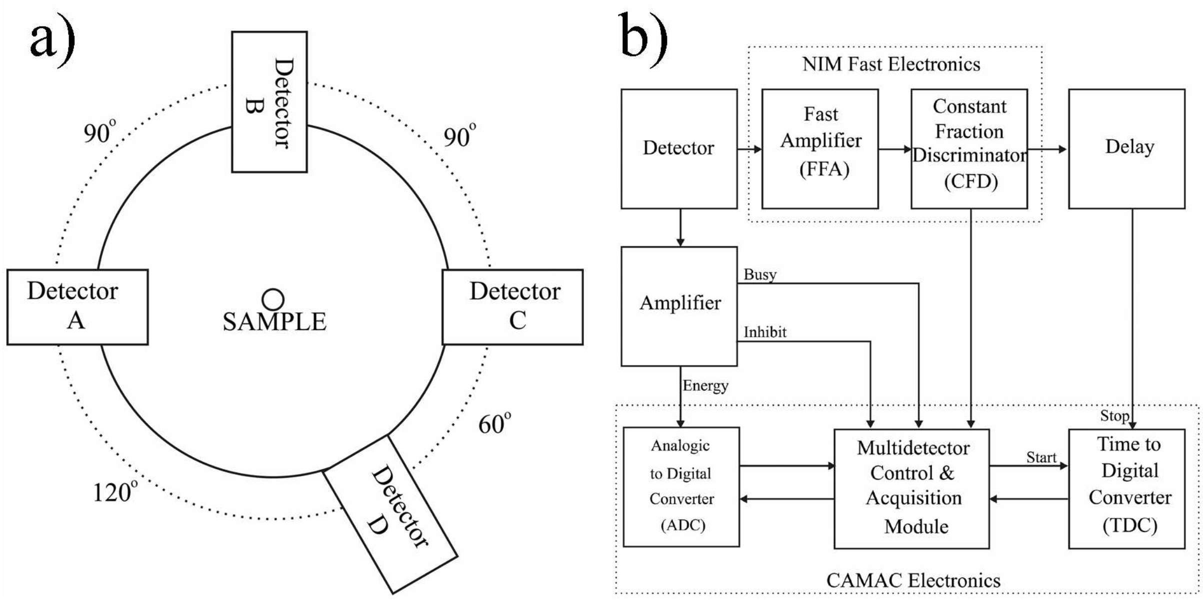

Figure 2. The experimental set-up:
a) Scheme of the planar detector setup used in the present measurements;
b) Electronic setup used in the present experiment; everything except for the CAMAC Electronics is independent for each of the 4 detectors used.

2.2 Data Analysis

The data was analyzed using the BIDIM software [9], which allows the subtraction of accidental coincidences, through the use of a time gate, and bidimensional fitting of the peaks with compensation for Compton scattering from other gamma rays. In order to make the analysis process more agile and less error-prone, the events from all 6 detector pairs (*AB*, *AC*... *CD*, corresponding to the scheme used in Fig. 2a) were relocated, in order to equalize their energy calibration curves.

Two different analyses were performed in this work; firstly, for the verification of the coincidence between the two γ-rays, the spectra from all six detector pairs were summed up to increase the overall detection efficiency - and, thus, the counting statistics; finally, for the angular correlation study, the six pairs were analyzed separately, in order to give individual results for each of them.

The procedure adopted for the angular correlation study was the one described by Genezini [10], with the solid angle correction factors (described in [11]) estimated using the values from [10] and uncertainties of 5%, which seems adequate to cover all possible values, propagated to the rest of the analysis.

3. RESULTS AND DISCUSSION

3.1 Coincidence Analysis

From the assumptions made by Price & Johns [7], namely that the coincidence peak found at E_1 = 362keV and E_2 = 299keV was due to remains of the strong 361.8keV transition and to a sum of the 99keV and 197keV transitions, one could expect that this bidimensional peak would have, on one hand, exactly the same energy of the 361.8keV transition and, on the other, an energy somewhat dislocated from that of the true 298.8keV transition. Fig. 3 shows the projection of the experimental bidimensional peak related to this coincidence, and from these results it is easy to see that neither of the aforementioned assumptions is true, as the peak has exactly the same energy of the 298.8keV transition and is clearly dislocated from the main 361.8keV line; both facts are strong evidences that this is a coincidence between the well-known 298.8keV γ transition and another transition with $E < 361.8$keV - in fact this transition's energy have been calculated as 361.721(16)keV.

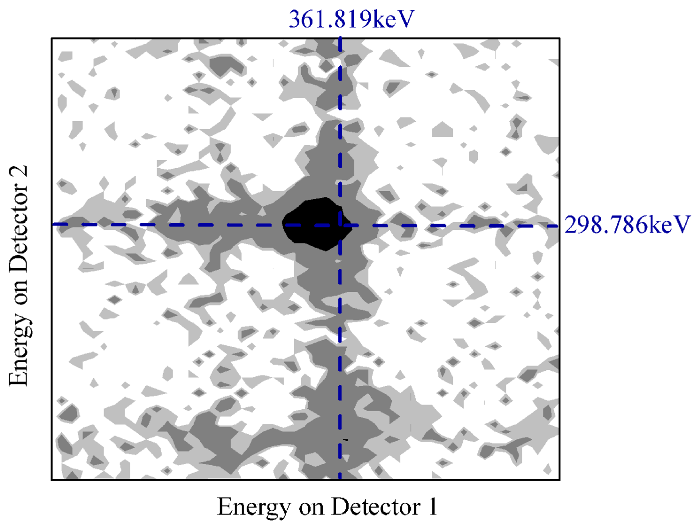

Figure 3. The bidimensional spectrum of the coincidence between the 361.7keV and the 298.8keV transitions.

3.2 Angular Correlation

Using the data from a previous work [6], the log*ft* of this level has been determined as 9.07(5), thus clearly indicating that the transition from the ground state of ^{193}Os to this level is a First Forbidden decay so, from the beta decay selection rules, it follows that the possible values for the spin of this state are 1/2+, 3/2+, 5/2+, and 7/2+.

In an attempt to further investigate this new level, as well as to try to reduce the possibilities for the level's spin, an angular correlation investigation of this coincidence was due. For the correct analysis of the possible spins of the 960keV level and of the multipole mixing ratio (δ) of the 361.7keV transition, it is essential to be sure about the mixing ratio of the other transition in this coincidence; although the 298.8keV transition is usually assumed to be a pure E2 one, it was decided to verify this assumption through the coincidence of this γ-ray with the strong, pure E2 transition at 219.1keV. The results of this analysis are shown in Table 1.

Table 1. Analysis of the multipole mixing ratio (d) of the 298.8keV transition.

Measurement	***Mixing Ratio (d)***
1	-0.15(21)
2	-0.23(23)
weighted average	-0.19(16)

From these results one can see that, although the mixing ratio of the 298.8keV transition is compatible with pure E2 (δ=0) for each of the two measurements, the weighted average is slightly indicative of a highly-unlikely E2+M3 mixture. For this reason, the analysis of the 361.7keV transition was performed by assuming, for each of the possible spin values for the 960keV level, either a mixing ratio of 0 (E2) or -0.19 (E2 + M3) for the 298.8keV transition. The results for these analyses are shown in Table 2:

Table 2. Analysis of the possible spins for the 960keV level.

Spin assignment	***d(298.8)*** ***(fixed parameter)***	***d(361.7)*** ***(adjusted parameter)***	c^2
1/2	-0.19(16)	-0.8(6)	1.22
1/2	0	*n/c*	*n/c*
3/2	-0.19(16)	-0.3(4)	1.22
3/2	0	*n/c*	*n/c*
5/2	-0.19(16)	*n/c*	*n/c*
5/2	0	*n/c*	*n/c*
7/2	-0.19(16)	*n/c*	*n/c*
7/2	0	*n/c*	*n/c*

n/c – fit did not converge properly

From the results in Table 2, it is possible to deduce that the angular distribution is consistent with a spin assignment of either 1/2 or 3/2 for the 960keV level.

4. CONCLUSIONS

From the analysis of the coincidence between the 298.9keV transition and the 361.7keV one it is possible to verify that this is a true coincidence between the well-known 298.786(11)keV transition and a new 361.721(16)keV one, confirming the previous results in [6]. The analysis of the log*ft* of this decay and of the angular correlation of this coincidence also allows the proposition of either a 1/2+ or a 3/2+ spin for this new level.

In an attempt to decide for either of the proposed spins, and also to further investigate the possibility of an E2+M3 mixture in the 298.9keV transition, the data in this work will be analyzed again, with the proper calculation of the solid angle correction factors for each detector involved in the measurement.

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