Communications

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K-capture probability (P_K) in the decay of ^{152}Eu (12.4 yr) and ^{192}Ir (74 day)

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From the analysis of the K x-ray–γ-ray sum peaks observed with a Ge(Li) detector the K-capture probability (P_K) for the 1529.8 keV and 1233.8 keV states of ^{152}Sm in the decay of ^{152}Eu (12.4 yr) and 690.5 keV state of ^{192}Os in the decay of ^{192}Ir (74 day) have been determined. The observed values are: $P_K^{1529.8} = 0.76 \pm 0.09$, $P_K^{1233.8} = 0.88 \pm 0.10$ and $P_K^{690.5} = 0.70 \pm 0.06$.

[RADIOACTIVITY ^{152}Eu, ^{192}Ir; measured sum-peak areas, I_γ, I_{Kx}; deduced P_K.]

In a recent article[1] the successful application of the sum-technique using a Ge(Li) detector for the measurement of P_K, the K-capture probability has been made for the two states of ^{133}Cs in the decay of ^{133}Ba (10.4 yr). The relative ease with which the P_K were determined has stimulated us to apply this technique to a few more isotopes especially where the data appear to be lacking. So far, to our knowledge, there have been no measurements done in the decay of ^{192}Ir (74 day). In the case of ^{152}Eu (12.4 yr) decay there has been only one measurement done for the 1529.8 keV state of ^{152}Sm.[2]

As a primary condition for the measurement of P_K by the sum technique, the decay schemes of the two isotopes are well known.[3,4] Figure 1 shows a part of the γ-ray spectrum of ^{152}Eu obtained with a 32.2 cm^3 Ge(Li) detector in the close geometry setup. Figure 2 shows the same in the decay of ^{192}Ir. Using the decay schemes of ^{152}Eu[3] and ^{192}Ir[4] the following equations for the sum peaks (1408.0 $+K\alpha$) keV and $(1112.1+K\alpha)$ keV in the decay of ^{152}Eu (Fig. 1) and $(484.7+K\alpha)$ keV in the decay of ^{192}Ir (Fig. 2) can be written to a good approximation as

$$N^{\text{sum}}_{1408.0+K\alpha} = f\left(P_K^{1529.8} + \frac{\alpha_K^{121.8}}{1+\alpha_T^{121.8}}\right) N_{1408.0}\,, \qquad (1)$$

$$N^{\text{sum}}_{1112.1+K\alpha} = f\left(P_K^{1233.8} + \frac{\alpha_K^{121.8}}{1+\alpha_T^{121.8}}\right) N_{1112.1}\,, \qquad (2)$$

$$N^{\text{sum}}_{484.7+K\alpha} = f\left(P_K^{690.5} + \frac{\alpha_K^{205.8}}{1+\alpha_T^{205.8}}\right) N_{484.7}\,, \qquad (3)$$

where N are the peak areas, $f=\omega_K f_{K\alpha}\epsilon_{K\alpha}$; ω_K is the K-fluorescence yield in the daughter nucleus, $f_{K\alpha}=I_{K\alpha}/I_{K\alpha}+I_{K\beta}$ and $\epsilon_{K\alpha}$ is the absolute efficiency for the $K\alpha$ x rays.

In the present work the values of ω_K and $f_{K\alpha}$ are taken from Bambynek *et al.*[5] and Hansen, Freund, and Fink,[6] respectively. The conversion coefficients of the γ rays entering into the above equations are taken from Hager and Seltzer.[7] For the determination of $\epsilon_{K\alpha}$ we use ϵ_γ measured from the analysis of the γ-γ sum peaks[8] of the particular isotope and the ratio $\epsilon_{K\alpha}/\epsilon_\gamma$ from the relative efficiency curve in the close geometry setup. For example $\epsilon_{K\alpha}$ (Sm) is determined from $\epsilon_{121.8}$ determined from the sum peak (1112.1 + 121.8) keV and the ratio $\epsilon_{K\alpha}/\epsilon_{121.8}$ from the relative efficiency curve.[4]

The data of the present work yield $P_K^{1529.8} = 0.76 \pm 0.09$, $P_K^{1233.8} = 0.88 \pm 0.10$ and $P_K^{690.5} = 0.70 \pm 0.06$. The result for the 1529.8 keV state is in good agreement with the value 0.79 ± 0.02 of Lu and Schupp measured from the coincidence experiment.[2]

It is interesting to see that the electron capture feeding in the ^{192}Ir decay is mostly through the 690.5 keV state (79%) of ^{192}Os (Ref. 4). Thus a direct measurement of total P_K from the K x-ray intensities should be comparable with $P_K^{690.5}$ determined from the analysis of the sum peak. Figure 3 shows the K x-ray part of the spectrum obtained with a high resolution (500 eV at 121.8 keV) Ge(Li)

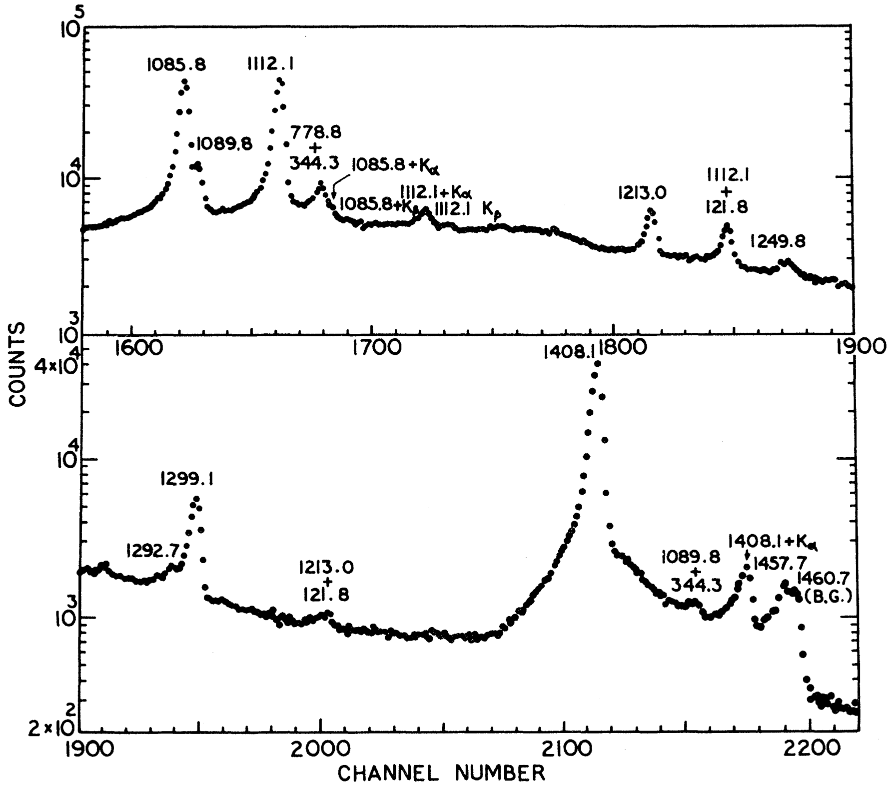

FIG. 1. A part of the γ ray spectrum of ^{152}Eu with the source on the top of the 32.2 cm^3 Ge(Li) detector. The high background in the region after 1408.0 keV is due to the summing of 1408.0 keV photopeak with the Compton distribution of the 121.8 keV γ ray.

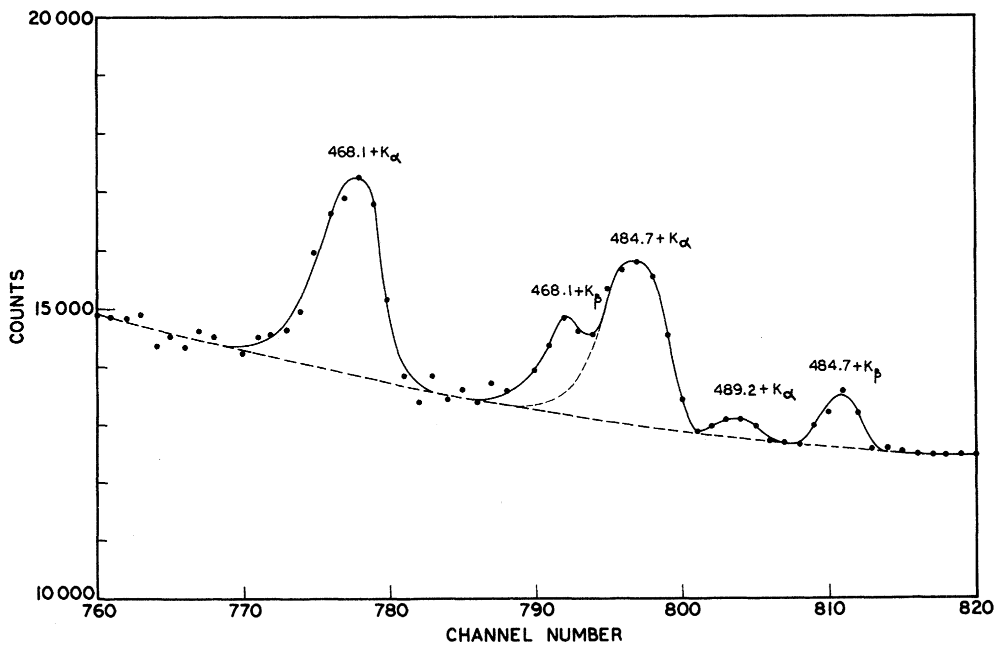

FIG. 2. A part of the γ ray spectrum of ^{192}Ir with the source on the top of the 32.2 cm^3 Ge(Li) detector.

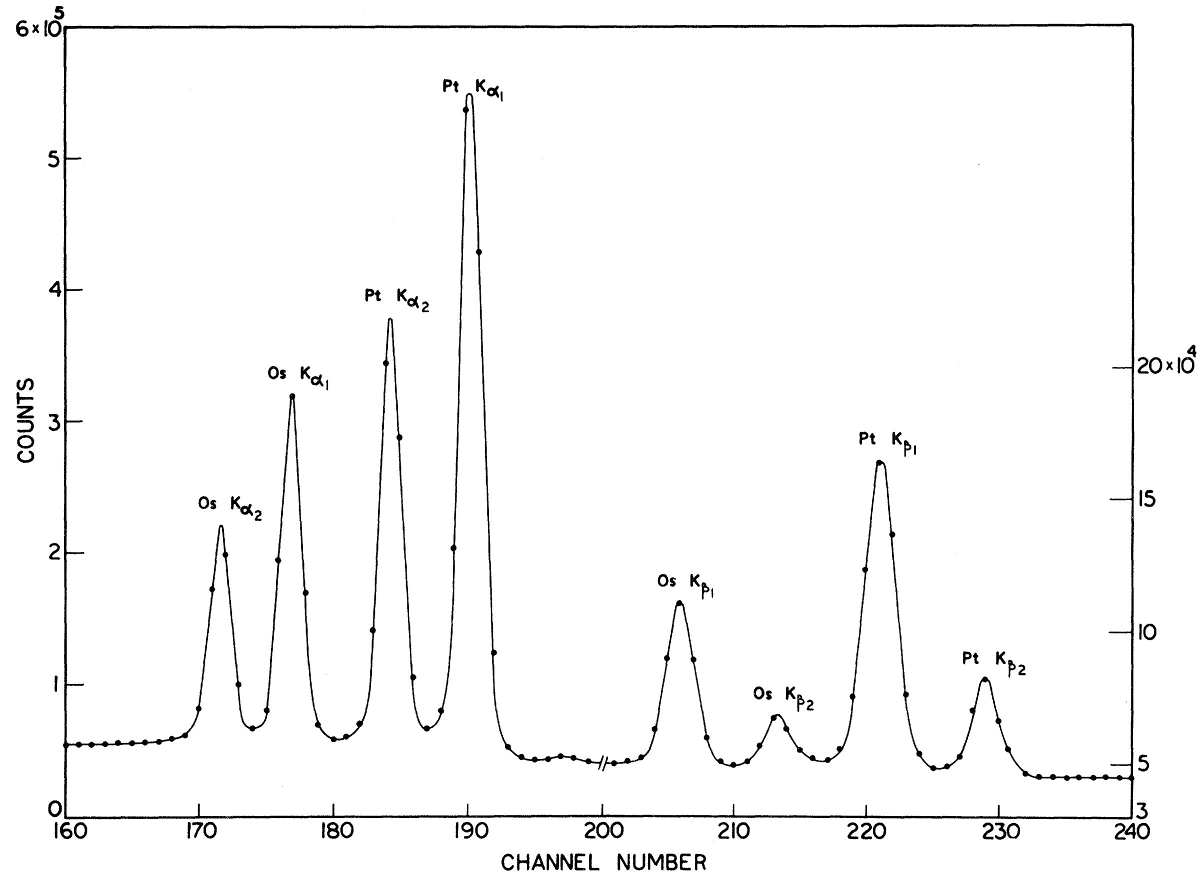

FIG. 3. A part of the low energy γ ray spectrum of ^{192}Ir obtained with the Ge(Li) x-ray detector showing the Os and Pt K x rays.

x-ray detector. Table I shows the results of the K x-ray intensity measurement in the ^{192}Ir decay which so far, to our knowledge, have not been reported. The $I_{K\beta}/I_{K\alpha}$ ratios for both the nuclei (^{192}Os and ^{192}Pt) agree fairly well with those measured by Hansen, Freund, and Fink.[6] With the relevant equations given in our earlier report[1] we obtain for ^{192}Os, P_K(total) = 0.70 ± 0.04 which is observed to be in good agreement with $P_K^{690.5}$ measured from the analysis of the sum peak.

TABLE I. Results of the measurement of K x rays in the decay of ^{192}Ir.

Energy[a] (keV)		Relative intensity
61.49	($\mathrm{Os}K\alpha_2$)	1.37 ± 0.07
63.00	($\mathrm{Os}K\alpha_1$)	2.39 ± 0.10
65.12	($\mathrm{Pt}K\alpha_2$)	3.00 ± 0.11
66.83	($\mathrm{Pt}K\alpha_1$)	5.13 ± 0.15
71.3	($\mathrm{Os}K\beta_1$)	0.81 ± 0.04
73.4	($\mathrm{Os}K\beta_2$)	0.21 ± 0.02
75.7	($\mathrm{Pt}K\beta_1$)	1.72 ± 0.06
77.8	($\mathrm{Pt}K\beta_2$)	0.48 ± 0.02
316.5		100

[a] The energies of the K x rays are taken from Lederer, Hollander, and Perlman (Ref. 11).

Because of the very poor statistics of the sum peak (374.5 + $K\alpha$) keV and the fact that the photopeak 374.5 keV contains appreciable contribution of the sum peak (308 + $K\alpha$) keV, the measurement of $P_K^{580.3}$ will be subjected to large uncertainty. Similarly in the ^{152}Eu decay, the $P_K^{1085.8}$ is difficult to

TABLE II. Results of the measurement of P_K in the decay of ^{152}Eu and ^{192}Ir.

Parent nucleus	Daughter nucleus	Level	P_K Expt.	P_K Theo. (see text)
^{152}Eu (3^-)	^{152}Sm	1529.8 (2^-)	0.76 ± 0.09	0.82
^{192}Ir (4^-)	^{192}Os	1233.8 (3^+)	0.88 ± 0.10	0.84
		690.5 (3^+)	0.70 ± 0.06	0.77

determine since in this case the two sum peaks (1085.8 + $K\alpha$) keV and (778.8 + 344.3) keV almost merge with each other within the detector resolution (Fig. 1).

Out of the three P_K measured in the present work $P_K^{1529.8}$ corresponds to an allowed transition and the other two ($P_K^{1233.8}$ and $P_K^{690.5}$) correspond to nonunique first-forbidden transitions. The comparison with the theoretical estimate is difficult for the latter type since the calculation of P_K for the nonunique transitions involve nuclear matrix elements which are usually not known. Nevertheless, assuming that the degree of forbiddenness is not very much sensitive to P_K,[9] we have compared the experimental results with the theoretical estimate[10] for the allowed decay (Table II). In view of the relatively large error associated with the measurement of P_K, a precise comparison with theory is difficult. It may be noted that the main source of error in the present work results from the measurement of efficiency of the detector for the K x rays which is difficult to minimize. However, with the uncertainty the present work shows that though the two P_K measured in the ^{152}Eu decay show good agreement with the theory, the P_K for the 690.5 keV state of ^{192}Os in the ^{192}Ir decay appears to be somewhat less which is further supported by the additional measurement of total P_K. It is interesting to see that if we assume the theoretical value (0.77) for the 690.5 keV state then in order to be consistent with the total P_K, the P_K for the 580.3 keV state is found to be 0.48 ± 0.07 (neglecting the contribution of the small feeding to the 909.7 keV level[4]) which appears to be significantly less compared to the theoretical value (0.79).

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[1]B. K. Dasmahapatra and P. Mukherjee, J. Phys. A 7, 388 (1974).

[2]D. C. Lu and G. Schupp, Bull. Am. Phys. Soc. 7, 353 (1962).

[3]L. L. Riedinger, N. R. Johnson, and J. H. Hamilton, Phys. Rev. C 2, 2358 (1970).

[4]P. Mukherjee and B. K. Dasmahapatra, J. Phys. A 7, 2008 (1974).

[5]W. Bambynek *et al.*, Rev. Mod. Phys. 44, 716 (1972).

[6]J. S. Hansen, H. U. Freund, and R. W. Fink, Nucl. Phys. A142, 604 (1970).

[7]R. S. Hager and E. C. Seltzer, Nucl. Data A4 (No. 1-2) (1968).

[8]B. K. Dasmahapatra and P. Mukherjee, Nucl. Instrum. Methods 107, 611 (1973).

[9]L. N. Zyryanova, in *Proceedings of the Conference on Electron Capture and Higher-Order Processes in Nuclear Decays, Debrecen, Hungary, 1968* (Eötvos Lóránd Physical Society, Budapest, Hungary, 1968), p. 5.

[10]M. J. Martin and P. H. Blichert-Toft, Nucl. Data A8 (No. 1-2) (1970).

[11]C. M. Lederer, J. M. Hollander, and I. Perlman, *Table of Isotopes* (Wiley, New York, 1967), 6th ed.