POSITRON DECAY OF Ir^{192}

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Positron decay of Ir^{192} ($T_{1/2}$ = 74 days) has been detected with the relative intensity 1.5×10^{-7} positron per decay and end-point energy 240 ± 10 kev. The total Ir^{192}-Os^{192} transition energy is 1950 kev. The conversion-electron spectrum above 1 Mev was measured. A new 1088-kev γ transition was detected.

1. INTRODUCTION

Ir^{192} is known to decay to Pt^{192} through β^- emission and to Os^{192} through electron capture. According to Wapstra[1] an Ir^{192}-Os^{192} transition through positron decay is also energetically possible. This decay has heretofore not been detected; in references 2 and 3 its intensity was estimated at less than 10^{-6} positron per decay.

2. EXPERIMENTAL PROCEDURE

Our measurements were obtained with the magnetic beta-ray spectrometer described in references 4 and 5. Iridium sources were prepared by thermal-neutron irradiation of metallic iridium deposited on 5 μ aluminum foil by means of cathode sputtering in an argon atmosphere. Material containing 99.92% Ir, 0.03% Pt and 0.02% Rh was sputtered. 18 × 8 mm sources were used. The spectrometer resolution was 1.5% with the solid angle 0.5% of 4π.

3. POSITRON SPECTRUM OF Ir^{192}

Correct allowance for the background is very important for the study of a very weak positron spectrum in the presence of intense beta and gamma radiation. The background is usually measured by shifting the source with respect to the slit placed before it so that beta rays with normal trajectories cannot enter the spectrometer. The background can also be measured when the diaphragm aperture is closed, but both procedures generally modify the background in such a way as to distort the results. Our beta-ray spectrometer was designed to permit background measurements by a different technique.

In our spectrometer the beta-ray beam which had traversed the first counter after being focused in a sectorial magnetic field was refocused by a

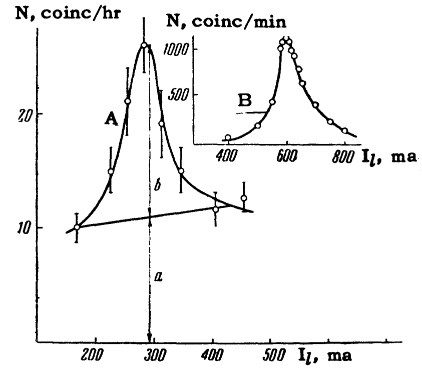

FIG. 1. A) dependence of counting rate on lens current in measurement of Ir^{192} positron spectrum (a – background, b – positrons); B) dependence of counting rate on lens current for β^- spectrum of Ir^{192}.

magnetic lens, which thus served as a second monochromator. Figure 1B shows the instrumental line for the magnetic lens that was obtained in measuring the electron spectrum. With constant current maintained in the magnet the lens focused beta rays in a small energy range which was determined from the spectrometer resolution. At the same time the background electrons have a very flat energy distribution since the background results mainly from Compton electrons, ejected by gamma rays in the region of the first counter, which enter the first counter and are subsequently focused at the second counter, as well as from beta rays undergoing multiple scattering at the walls and baffles. Consequently, when the lens current is varied within certain limits while the magnet current remains constant the registered radiation will not change much if it results from the background. However, if positrons focused by the sectorial field are being registered the beam intensity will vary as shown by the curve in Fig. 1B. Figure 1A shows how the coincidence intensity observed by us in the study of the Ir^{192} positron spectrum depends on the lens current. Here the background a can be very simply separated from the positron spectrum. The principal advantage of the given technique for background measurements lies in the fact that the position of the source and the conditions for beam passage are not varied.

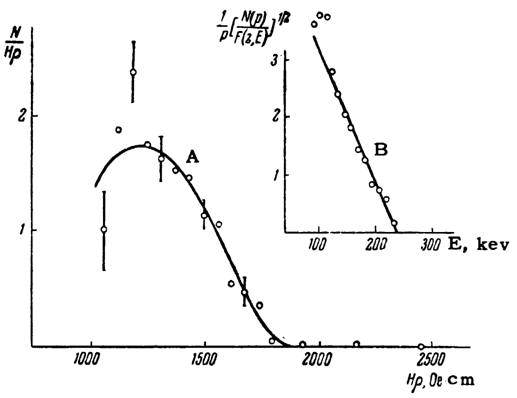

FIG. 2. A) Ir^{192} positron spectrum; B) Fermi plot for positron spectrum.

The positron spectrum of Ir^{192} is shown in Fig. 2 (curve A), where the background was taken into account and a correction was made for the dependence of detector efficiency on positron energy, just as in the case of the earlier work described in reference 5. A Fermi plot (Fig. 2B) shows that the positron spectrum results basically from β^+ decay with end-point $E_0 = 240 \pm 10$ kev. The half-life of the positron spectrum is estimated to be $T_{1/2} = 120 \pm 60$ days. On the basis of the end-point and half-life the observed spectrum is assigned to positron decay of Ir^{192}. Available data[6] indicate that the observed β^+ spectrum cannot be accounted for by impurities.

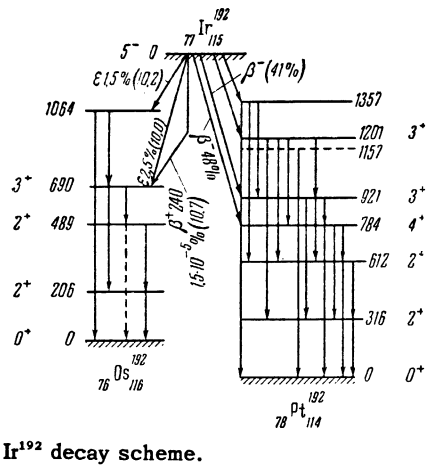

FIG. 3. Ir^{192} decay scheme.

Figure 3 shows the decay scheme[6] of Ir^{192} including the observed β^+ decay. Because of the relatively low statistical accuracy of the experimental data the corresponding unique shape of the β^+-decay spectrum was not determined. The total Ir^{192}-Os^{192} decay energy is 1950 ± 10 kev according to our data, in good agreement with the value 2050 kev obtained by Wapstra using a different procedure.[1]

By comparison with the β^- spectrum the β^+-decay intensity was determined to be $(1.5 \pm 0.4) \times 10^{-7}$ positron per decay. The observed spectrum is the weakest of the partial β spectra known at the present time. According to the decay schemes in reference 6 the K-capture intensity in Ir^{192} with a transition to the 690-kev excited state of Os^{192} is 2.5%. The K-capture to β^+-decay intensity ratio thus becomes $J_K/J_{\beta^+} = 1.6 \times 10^5$, which is about eight times larger than the result obtained by a calculation based on previously published data for allowed transitions[7,8] but which agrees very well with Zyryanova's results[9] for unique transitions.

4. INTERNAL CONVERSION SPECTRUM OF Ir^{192} GAMMA RADIATION ABOVE 1 Mev

The high-energy γ transitions that accompany Ir^{192} decay exhibit low intensities, the data for which are inadequate and to a certain extent inconsistent. No data have been available for the internal conversion spectrum of these hard gamma rays. We have investigated the spectrum of conversion electrons produced by gamma rays with energies above 1 Mev by means of the same apparatus that was used to measure the positron spectrum. The low background and negligible effect of scattered radiation make this spectrometer, as is evident from the data given below, a convenient instrument for investigating the internal conversion of very weak gamma radiation ($10^{-4} - 10^{-5}$ quanta per decay) when the conversion lines lie outside the β^- spectrum.

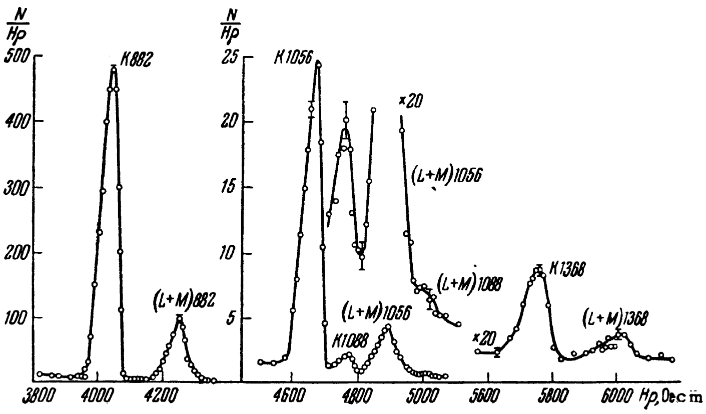

FIG. 4. Spectrum of Ir^{192} conversion electrons.

The results are shown in Fig. 4. We have included measurements of previously investigated

E_γ, kev	882±5	1056±5	1088±10	1368±10
Internal conversion ratio K/(L + M)	4.05	5.40	4.80	3.70
Multipolarity	$E2$ *	$E1$	$E1$ ($M1$)	$E3$ ($M3$)
Relative intensity of K-conversion lines	100	5.6	0.22	0.23
Relative gamma-ray intensity	100	21	0.8 (0.1)	0.3 (0.08)
Gamma-ray intensity	100	27 [10], 16 [11]	—	0.6±0.5 [12]

*E2 according to reference 3.

conversion lines resulting from a 882-kev gamma ray for the purpose of comparing intensities. Three gamma rays, with 1056, 1088 and 1368 kev, were observed in the energy region above 1 Mev. The difference between the K- and L-conversion energies indicates that the 1056-kev quantum is converted in Os^{192} while the other two quanta are converted in Pt^{192}. An analysis of the conversion spectrum yields the energies, multipolarities and relative intensities of these gamma rays, which are given in the table.

Multipole orders were determined from the K/L ratios with M-conversion taken into account through the ratio L/M = 3.5. Whenever a unique multipole order could not be determined a second less likely type is given in parentheses. Correspondingly, two values of the relative intensity are presented. The table shows that the 1056- and 1368-kev intensities agree in general with values given in the literature.[10-12]

The 1088-kev gamma ray was the first to be observed. This transition cannot be included in the Ir^{192} decay scheme shown in Fig. 3 without introducing an additional level. According to our data the 1056-kev transition is of type E1, which, as shown by the Ir^{192} decay scheme, disagrees with the value of log τf for the corresponding K-capture branch and with the relative intensity of the 1060- and 374-kev gamma rays.

It should be noted that, like the authors of reference 12, we failed to detect 1157- and 1201-kev gamma radiation. The corresponding intensities must in any event be considerably lower than those reported in references 11 and 13.

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