Gamma-Gamma Directional Correlation in Pt^{192}†

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Spins have been tentatively assigned to the first five states of Pt^{192}, the proposed spin sequence being 0, 2, 2, 3 (4), 4. The 296- and 468-kev transitions appear to be dipole-quadrupole mixtures. For the former, the percentage quadrupole radiation is 97.5% and for the latter, 5.8%.

THE gamma rays associated with the beta activity in 70-day Ir^{192} have been studied extensively in recent years.[1–5] Although energy and intensity measurements have been made, little information has been reported on the spins of the nuclear levels of the daughter nucleus Pt^{192}.[6] The present paper is concerned with the measurement of some of these spins by means of gamma-gamma directional correlation experiments.

The source used in the investigation was a small cylinder of pure iridium metal which had been irradiated in the Chalk River pile. It was mounted in a Lucite cylinder having $\frac{1}{16}$-in. thick walls, and had a strength of approximately 0.01 mC. The source was suitably aged to eliminate the activity of 19-hour Ir^{194}. Sources of different physical and chemical form were not available for this investigation and thus it was possible to study directional asymmetries in the coincidence rate for the metallic form only. However, since no isomeric state with a lifetime $>5\times10^{-9}$ second has been found[7] for this isotope, it is reasonable to assume that little or no perturbation of the correlation occurs in this case.

The detectors were conventional scintillation counters employing 1-in. cylindrical NaI(Tl) crystals and DuMont 6292 photomultiplier tubes. The pulses from the counters were amplified and fed into single-channel differential discriminators.[8] The output signals from the analyzers were fed into a Harwell type 1036 A coincidence unit ($\tau=0.1$ μsec). Three scalers were used to record the coincidence rate and the single counting rates for each spectrometer. The resolving time of the coincidence unit was measured several times each day by delaying the pulses from one detector by 1 μsec and measuring the different rates mentioned above.

A proposed level scheme for Pt^{192} is shown in Fig. 1.[4] The nuclear levels with which this investigation was concerned are those at 921, 784, 612, 316 kev and the ground state. The first cascade studied is that formed by the 468- and 316-kev gamma rays. The gate of one discriminator was set to accept pulses lying in the 468-kev photoelectron line of the gamma-ray pulse-height distribution, while the gate of the other was set on the multiple photoelectron line containing the 308-, 296- and 316-kev gamma rays. (The pulse-height distribution in this investigation was essentially the same as that given in reference 4.) It was noted that any interfering cascades contributed a negligible amount to the observed coincidence rate. The data were fitted by least squares to the correlation function $1+A_2P_2(\cos\theta)+A_4P_4(\cos\theta)$. The coefficients, uncorrected for angular resolution, were found to be: $A_2=0.0928\pm0.038$, $A_4=0.0052\pm0.047$. The experimental points and this correlation function (full line) are shown in Fig. 2. Since Pt^{192} is an even-even nucleus, it was assumed that the ground-state spin was zero and the spin of the first excited state was 2. Of the following spin sequences: 1–2–0, 2–2–0, 3–2–0, and 4–2–0, only the last two give correlation functions in agreement with observation. The last spin sequence gives values for A_2 and A_4 which agree with the measured values (after correction for angular resolution), but it is difficult to reconcile a spin of 4 with the existence of a crossover transition from the 784-kev level. With the 3–2–0 assignment, however, it is possible to get rough agreement with experiment only if the 468-kev transition is a dipole-quadrupole mixture. The dotted curve of Fig. 2 shows the function (uncorrected for angular resolution) associated with the 3(94.2% D, 5.8% Q)2(Q)0 spin sequence. The mixed radiations are 180° out of phase. The value of A_4 in this case is -0.0033, which although negative, is not inconsistent with the least-squares value in view of the relatively large statistical errors on the points of Fig. 2. It is apparent from this figure that the data are not sufficiently precise to decide between the 4–2–0 and 3–2–0 spin assignments. However, the observed intensity of the crossover transition from the 784-kev level does appear to favor the latter assignment to some extent.

The complexity of the gamma-ray spectrum associated with Ir^{192} prevented the study of any additional isolated cascades. However, a superposition of three 2-component gamma cascades was examined with some

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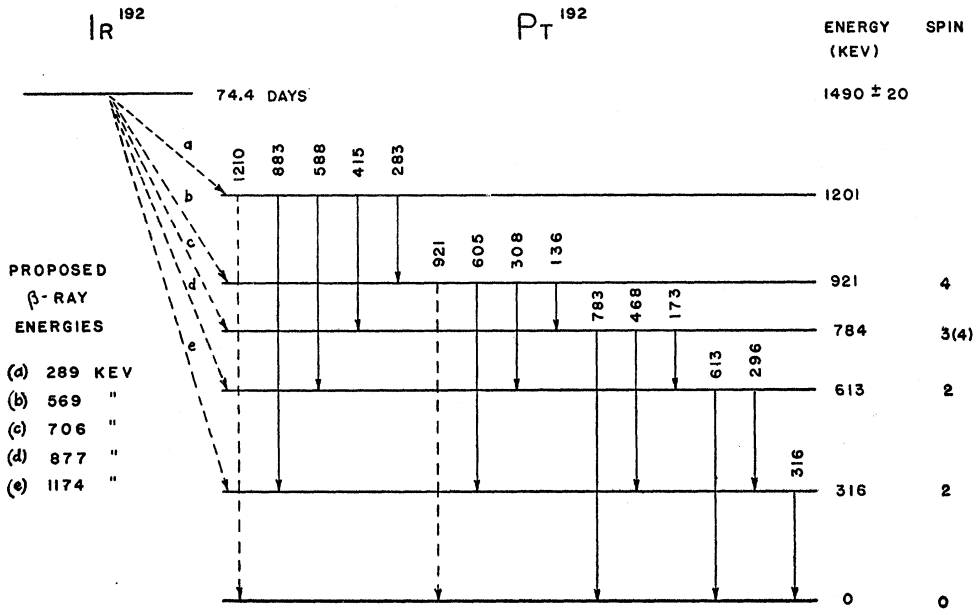

FIG. 1. Level scheme of Pt^{192} following Pringle *et al.* The spins shown are tentative values proposed here. It is likely that the parities of the first three levels are even.

success. In this case, the gate of each discriminator was set on the main photoelectron line of the gamma-ray spectrum. The observed coincidences were due to the following 2-component cascades: 468–316 kev (discussed above), 308–296 kev, 296–316 kev, and 308–316 kev. The last cascade gives a first-third type of correlation.[9] The data were fitted by least squares to an expression of the form $1+A_2P_2(\cos\theta)+A_4P_4(\cos\theta)$. After correction for the effect of the 468–316-kev cascade, and the finite angular resolution of the detectors, the coefficients were found to be $A_2=-0.0803\pm0.058$, $A_4=0.1040\pm0.065$. Using the known intensities of the 308-, 296-, and 316-kev gamma rays, and the spins assigned to the ground and first excited states, the form of the observed correlation function was calculated for various spin assignments for the 612- and 921-kev levels. In each case it was assumed that that one of the 308- and 296-kev transitions which involved the smaller spin change was a dipole-quadrupole mixture. (The absence of a crossover transition from the 921-kev level in Johns' work[5] suggested that the spin of this level is >3 units.) The only function which agreed with the experimental form was that corresponding to the spin assignment $4(Q)2(2.5\%\ D,\ 97.5\%\ Q)2(Q)0$ for the levels concerned. The mixed radiations of the intermediate transition are 180° out of phase. All other assignments gave either imaginary values for the Q-D mixing ratio, or correlation functions which did not extend to terms in P_4. The rather large quadrupole admixture in this case is not unique. Similar cases have been pointed out by Schiff and Metzger.[10]

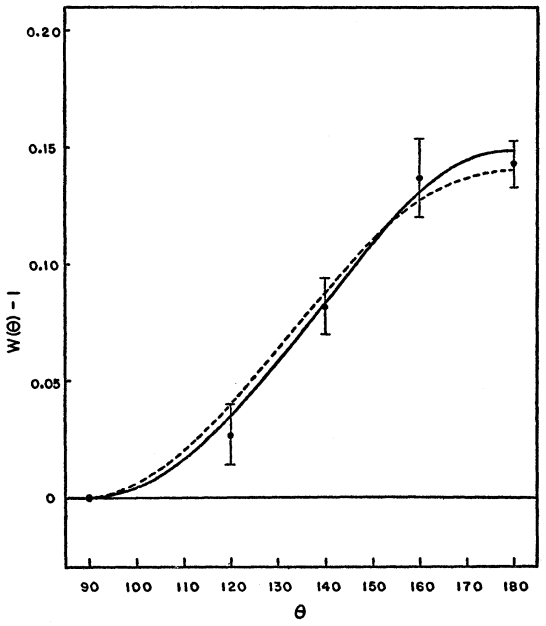

FIG. 2. Directional correlation of the 468–316-kev cascade of Pt^{192}. Full curve:—Least-squares fit of the data to $A_2P_2(\cos\theta)+A_4P_4(\cos\theta)$. Dashed curve:—Correlation function for the spin assignment $3(94.2\%\ D,\ 5.8\%\ Q)2(Q)0$. Corrections for angular resolution have not been applied to these data.

It is interesting to note that Johns[5] finds that the logft values for the β^- transitions of Ir^{192} are suggestive of first forbidden transitions. From the calculated logft values and the gamma-ray intensities, he proposes a spin of $4(-)$ for Ir^{192}. Although the present investigation is parity insensitive, the assignment of even parity to the levels discussed here would be consistent with the logft values for the β^- transitions and the general properties of even-even nuclei.

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