BETA-GAMMA DIRECTIONAL CORRELATION MEASUREMENT IN ^{191}Ir

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ABSTRACT

The angular correlation of the $1^- \xrightarrow[\beta]{1920\ keV} 2^+ \xrightarrow[\gamma]{329\ keV} 0^+$ cascade is measured integrally and at two beta energies. The results show isotropic correlation and indicate the validity of the ξ or coulomb approximation for the 1920 keV beta transition of ^{191}Ir.

INTRODUCTION

THE odd-odd iridium nucleus has 77 protons and 117 neutrons, lying between highly deformed and nearly doubly magic spherical nuclei. It decays with half life 17 hrs to the even-even ^{194}Pt *via* beta decay populating a number of positive parity states. The ground state of ^{194}Ir has 1^- character and the following beta transitions to ^{194}Pt are thus of non-unique first forbidden type. Information on beta decay observables and the concerned matrix elements in this region will be of great importance from a theoretical point of view as several approaches have been suggested to describe the nuclear levels. And, in particular, the Nilsson model and the quasi-particle description of the nuclear states have been tried to explain the various experimental results.

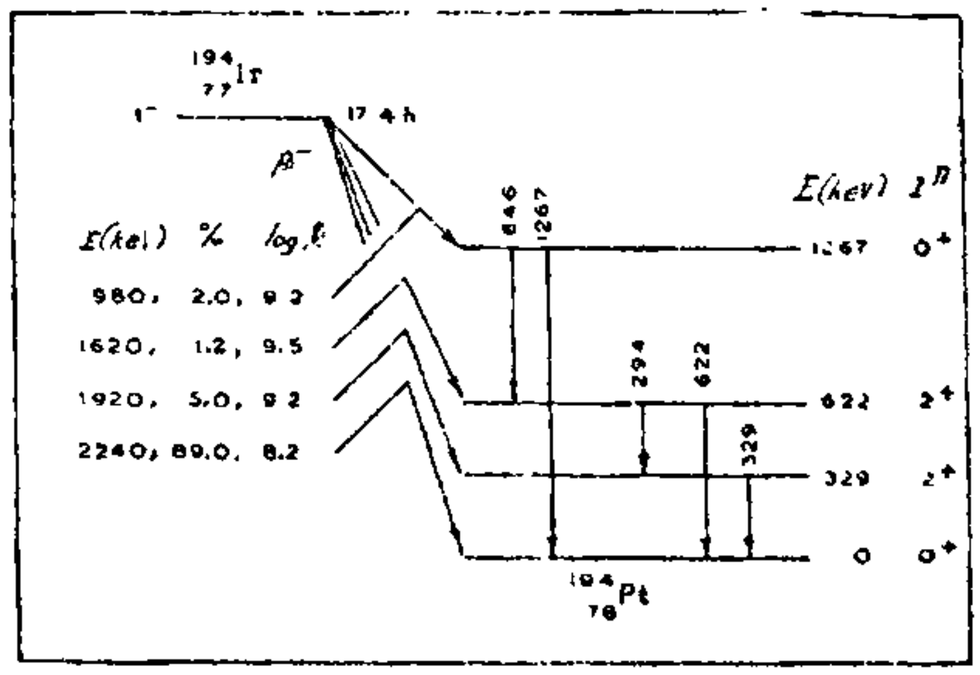
A partial decay scheme of ^{194}Ir of present interest and as taken from Ref. 1 is shown in Fig. 1. The $1^- \xrightarrow[\beta]{1920\ keV} 2^+ \xrightarrow[\gamma]{329\ keV} 0^+$ cascade is of present interest. The 1·92 MeV beta component from ^{194}Ir feeding the first excited state of ^{194}Pt with 329 keV energy has an intensity of 5·1% and log ft value 9·2. The ξ-value for this is 10·04 and is much greater than W_0-1 ($= 3{\cdot}758$), where W_0 is the end-point energy expressed in m_0c^2. Thus the ξ-value is consistent with the number expected for high Z nuclei. A study of beta-gamma anisotropy will be useful to test the validity of ξ-approximation. There was only one earlier measurement on the shape and angular correlation concerning the 1·92 MeV beta transition by Deutsch *et al*[2]. They report a statistical shape and isotropic angular correlation consistent with the validity of ξ-approximation. In the present study a reinvestigation of the beta-gamma angular correlation of the $1^- \xrightarrow[\beta]{1920\ keV} 2^+ \xrightarrow[\gamma]{329\ keV} 0^+$ cascade is considered to confirm the earlier measurement and the results are discussed for the applicability of ξ-approximation.

EXPERIMENT AND RESULTS

The experiment is carried out on a conventional slow-fast scintillation assembly, associated with a two-channel arrangement. A 1½" × 1" NaI (Tl) crystal optically coupled to a RCA 6810–A photomultiplier accomplishes gamma detection. A conical lead shield houses the gamma crystal for collimation of gamma radiation. The beta detector is a plastic scintillator with conical well cut in it to reduce low energy tailing arising out of backscattering effects. The source, being situated at the apex of the conical well, the effective solid angle is about 2% of 4π.

^{194}Ir source was obtained in liquid form as Sodium iridate in HCl from Bhabha Atomic Research Centre, Bombay (India). The source for the present measurements was prepared on a mylar film of thickness 0·6 mg/cm^2 over an area of 3 mm, the source film being glued to a very thin aluminium ring of diameter one inch.

Integral correlation.—From Fig. 1 it may be noted that only betas of energy above 1·6 MeV cascading



Decay scheme of Ir-194

FIG. 1

with the 329 keV gammas are free of interferences from the other cascades. At this energy as the intensity will be low, first the integral correlation experiment was performed to have an idea of the beta-gamma anisotropy. In this, betas of energy 1·6 MeV and above were accepted in the beta channel while the 329 keV gammas were accepted in the gate as indicated in Fig. 2. The coincidence data were collected at three angles 90°, 135° and 180° to compensate for the short half life 17 hrs of ^{194}Ir. The pooled up coincidences are corrected

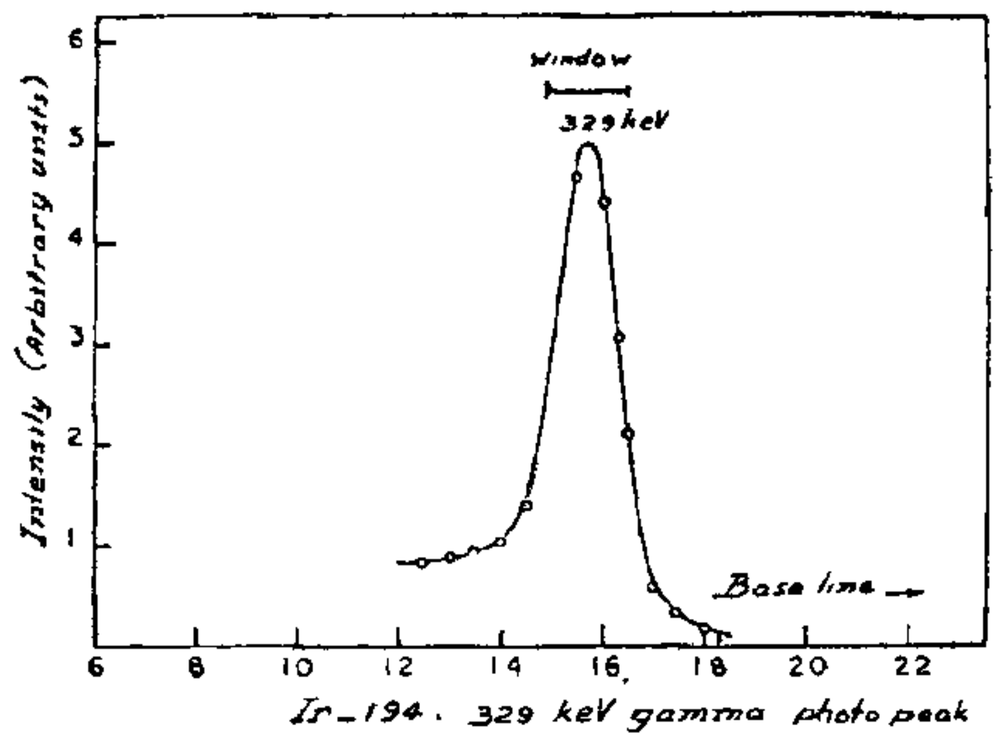


FIG. 2

for chance and background and normalised to the corresponding singles counts from the movable gamma detector. After applying the geometrical corrections to A_{22} and A_{44}, the following β–γ angular correlation function is obtained, by employing White's formulae[3].

$$W(\theta) = 1 + (0\ 003 \pm 0{\cdot}01)\,P_2(\cos\theta) + (0\ 005 \pm 0{\cdot}0397)\,P_4(\cos\theta)$$

The integral correlation results are shown in Fig. 3 as a function of θ. The straight line nature of the plot shows the absence of the A_{44} coefficient in the angular correlation function, thus establishing the non-unique first forbidden nature of the 1·92 MeV beta transition in ^{194}Ir.

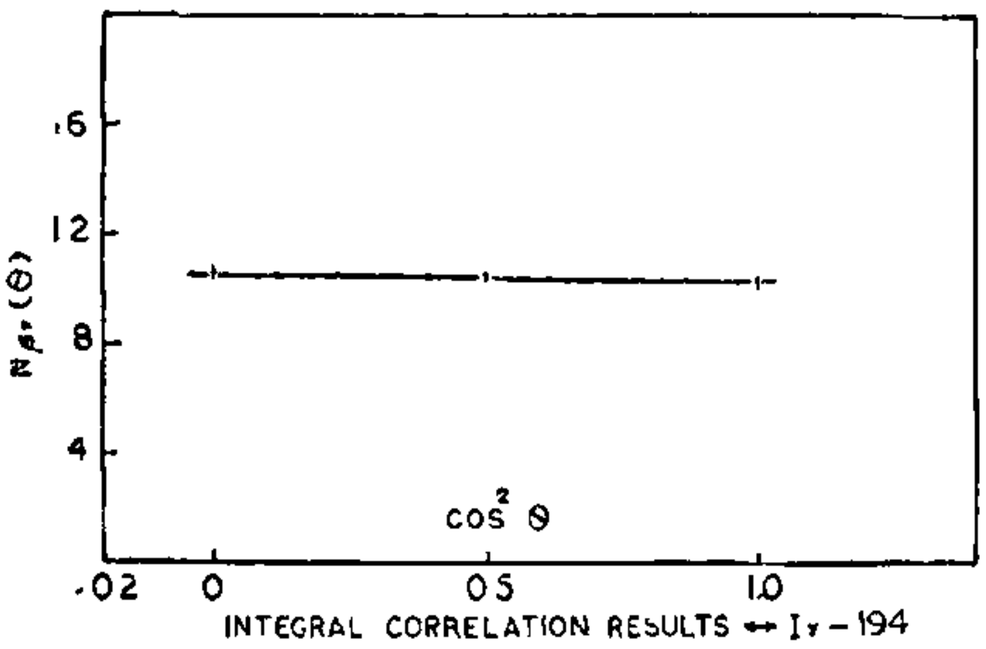


FIG. 3

Differential correlation.—These measurements were performed at two beta energies 4·22 and 4·351 (in m_0c^2 units) in a window of 75 keV. The coincidences were collected at 90° and 180° and all the corrections were applied to the observed coincidences to get the true coincidences. The following A_{22} coefficients are obtained at the two beta energies after applying the geometrical corrections.

Beta energy in m_0c^2 units	Correlation coefficient
4·22 (=1·6375 Mev)	0·005 ± 0·009
4·351 (= 1·7125 MeV)	0·002 ± 0·009

The results of both integral and differential correlation clearly establish that the beta-gamma angular correlation is isotropic within experimental uncertainties, in confirmity to the results reported by Deutsch *et al.*

DISCUSSION

The large ξ-value and the isotropic angular correlation support the validity of the ξ· or coulomb approximation for the 1·92 MeV beta transition in ^{194}Ir. The statistical shape of the same reported by Deutsch *et al.* confirms this conclusion. It is normally difficult to obtain nuclear matrix elements of beta transitions following ξ-approximation unless, the number of available experimental observables are large. And such an attempt could be successfully made only in the case of the 960 keV beta transition of ^{198}Au (ref. 4) which follows the ξ-approximation. A similar attempt can also be made for the present beta transition if data on different types of polarisation are available. In the absence of it there is not much to say anything about the validity of model predicted matrix elements. However, Deutsch *et al.* make an attempt for the determination of the nuclear matrix element parameter ratios u/x and z/x using their experimental data on C (W) and ϵ (W). In this, they assumed the validity of the CVC relationship due to Fujita and employed the approximate formulas of Kotani[5]. However, in the light of Damgaard and Winther[6] hypothes's and Buhring's[7] formulae (with Simms[8] method of application), the attempt of Deutsch is only an approximation.

From the present measurements on beta-gamma directional correlation it may be concluded that the 1·92 MeV beta transition of ^{194}Ir follows ξ-approximation.

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