LONGITUDINAL POLARISATION OF BETA PARTICLES FROM Rb^{86}, Pr^{144} AND Co^{60}

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Introduction

The two component theory of the neutrino expects the degree of longitudinal polarisation of the beta particles emitted in beta decay to be equal to v/c (Lee and Yang, 1957; Landau, 1957; Jackson *et al.*; A. Salam, 1957). Various methods of detecting and measuring this degree of polarisation have been reported so far (C. S. Wu, 1957). In this work, the measurements of the degree of polarisation of beta particles from Rb^{86}, Pr^{144} and Co^{60} using the method of Mott scattering are reported. This method is particularly suitable for low energy electrons as one can obtain a higher asymmetry in the counting rates by using a high Z material like gold for the scatterer.

Experimental Arrangement

The experimental arrangement is schematically shown in Fig. 1 (also *see* Plate XIX). The conversion of longitudinal polarisation of the beta particles to transverse polarisation was achieved by means of an electro-static cylindrical condensor, consisting of two concentric sectors of cylinders with mean radius 5″ and gap $\frac{1}{2}$″ (Tolhoek, 1956). The aluminium electrodes and the perspex spacers which held them firmly were both accurately machined. The angle of the electrode sector was 115°, so that the condenser could be used to give conversion of polarisation for electron energies from 90 KeV to 150 KeV (Tolhoek, 1956). The electron beam transversely polarised, emerges through the condenser, passes through the slit, and suffers Mott scattering at the gold foil F, which makes an angle of 45° with the direction of the beam. The electrons scattered in an angular interval of $90 \pm 9°$ are counted by means of end window G.M. counters in the side channels, and the asymmetry in the counting rates L/R is determined. The convention for Left (L) and Right (R) used here is the same as given by Fraunfelder (Fraunfelder *et al.*, 1957). Electrons going through the foil vertically are counted by the top G.M. counter marked Monitor.

The end window G.M. counters have mica windows about $1 \cdot 6$ mgm./cm.^{2} thick and about 1″ in diameter. They are surrounded by lead rings to reduce the background counting rate. The entire scattering assembly along with the gold scatterer F could be rotated about the beam without disturbing the vacuum. The scatterer could be separately turned from outside so as to make any desired angle with the beam.

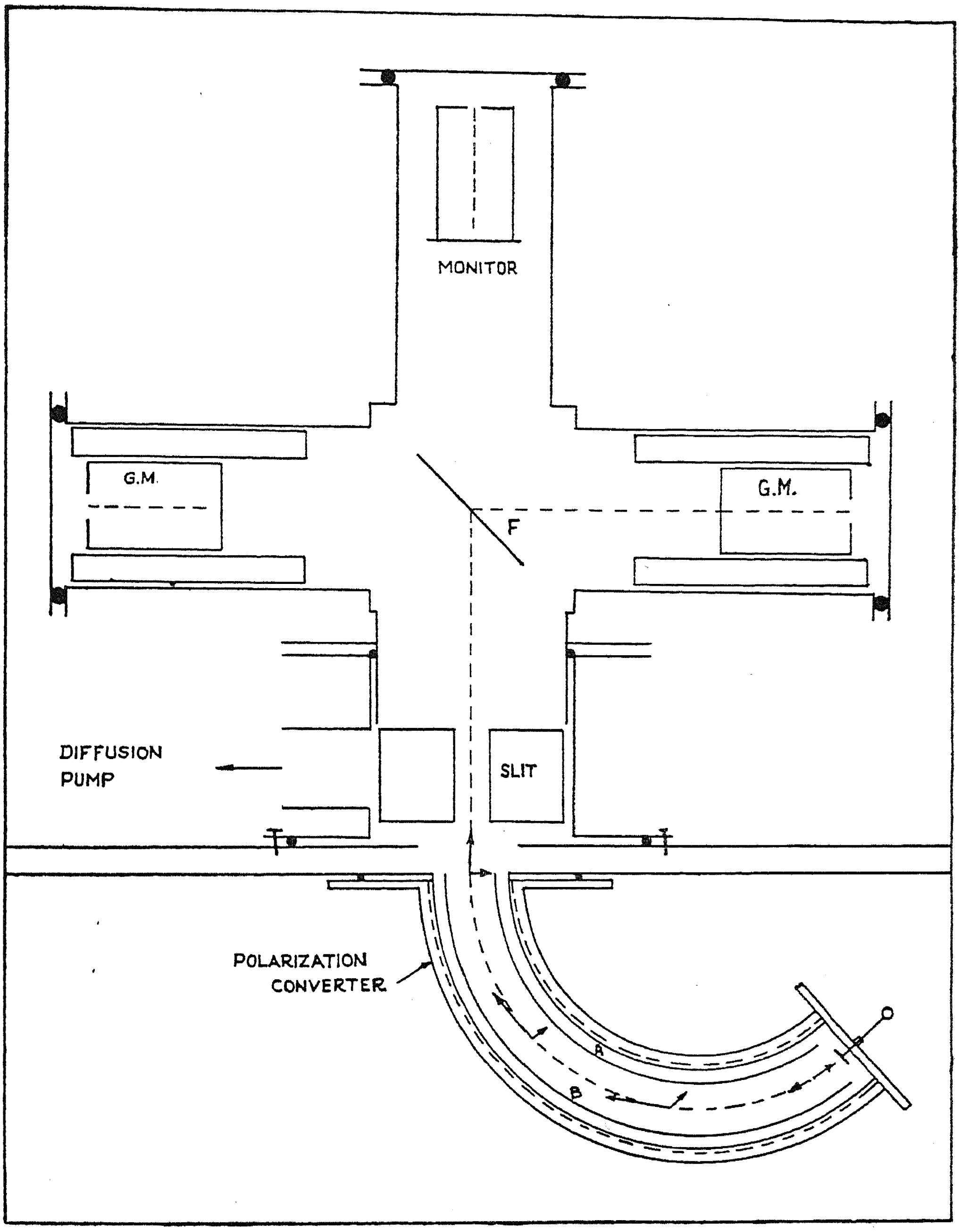


FIG. 1. Converter and Scatterer Assembly.

The gold scatterer F was prepared by evaporating gold on a collodian film about 50 μgm./cm.^{2} thick, carefully prepared to avoid any frills. The thickness of the gold deposited was about 75 μgm./cm.^{2} This precaution is essential as higher thickness of the scatterer results in plural scattering which tends to decrease the observed degree of polarisation (Shull, 1943). Sources were prepared on plastic films 85 μgm./cm.^{2} thick. In all cases the source thickness was estimated to be less than $0 \cdot 2$ mgm./cm.^{2} The sources were obtained from Harwell, and were of very high specific activity. Care was taken to earth the sources.

The side channels were adequately shielded, so as to maintain a background of $21 \pm 0 \cdot 8$ counts/min. The background with the electron beam 'on' but the scatterer withdrawn was $25 \pm 0 \cdot 8$ counts/min. indicating a very low contribution due to the scattering from the walls of the scattering assembly. The counting rate due to the scattering from the gold foil was of the same order of magnitude as the background counting rate.

The diameter of the beam at F was measured by replacing the scatterer by an aluminium absorber and checking the counting rate with the monitor counter for various angles of the absorber with respect to the beam. The diameter of the beam was estimated to be $\frac{1}{2}''$ at F. To test the instrumental asymmetry, if any, aluminium was used as the scatterer instead of gold and the left-right asymmetry was checked. This was found to be very small namely $L/R = 1 \cdot 01 \pm 0 \cdot 02$ as compared to the asymmetry with gold as the scatterer which was $L/R = 1 \cdot 23 \pm 0 \cdot 03$ for Tm^{170} as the source.

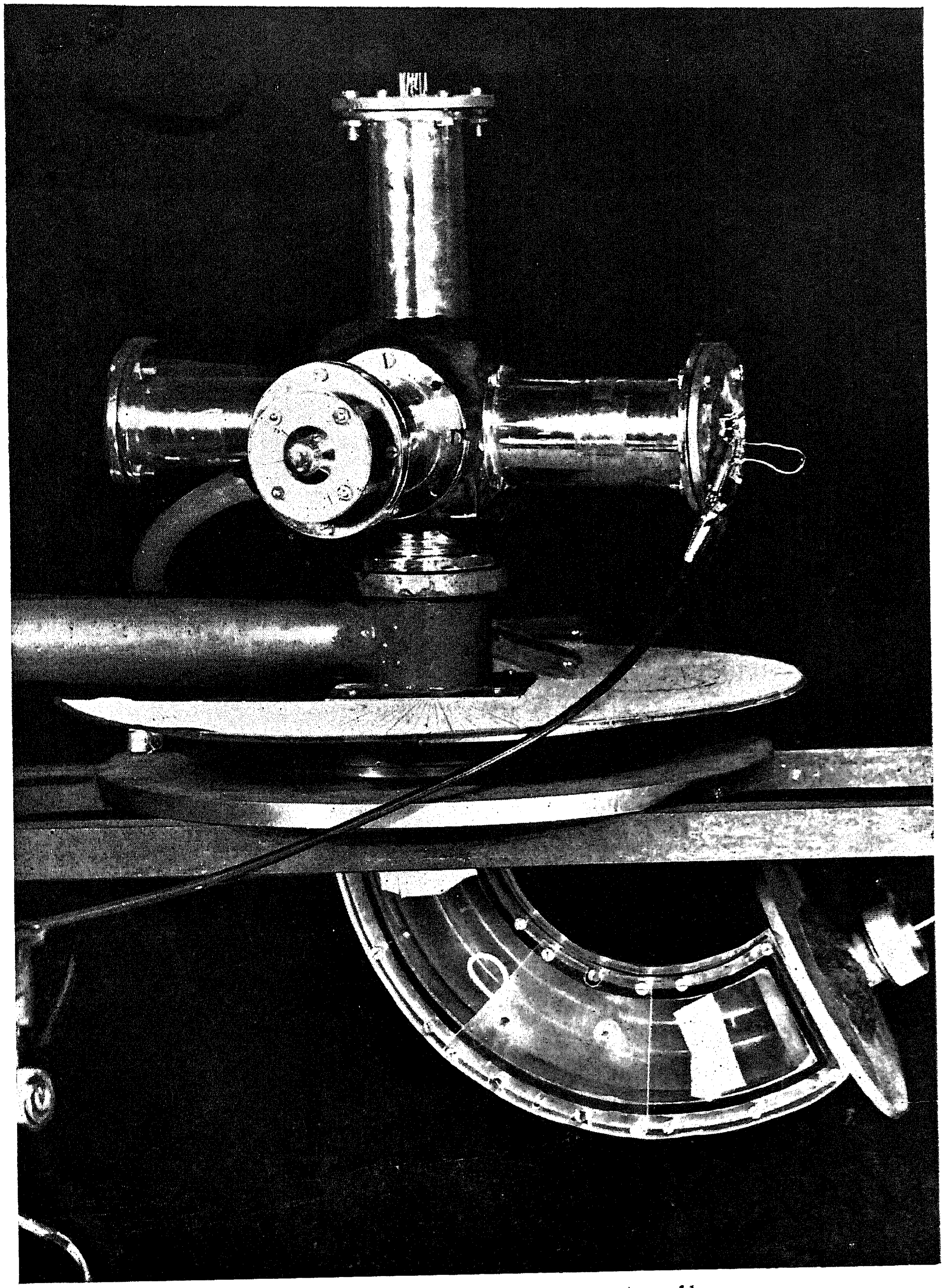
The uniformity of the gold foil was tested by rotating the foil through 180° in its plane and carrying out the experiments again. The two observations were in good agreement within experimental error which was less than 2%. The stability of the entire set up was tested for several hours, and the reproducibility was ensured by taking several sets of observations in each case.

The degree of polarisation P is calculated from the relation,

$$\frac{L}{R} = \frac{1 + Pa(\theta)}{1 - Pa(\theta)}$$

where $a(\theta)$, the polarisation asymmetry factor for scattering angle θ, and for a given energy, has been taken from Sherman's tables (Sherman, 1956). The values of P obtained for various sources for the transmission position of the scatterer are given in Table I.

These results show that for allowed and first forbidden transitions of both Fermi and G.T. type of interactions the degree of polarisation P obeys $-V/C$ law, for the energy investigated here (110 KeV). The slight difference between the observed and the theoretical values of P can be attributed in



Polarization Converter and Scatterer Assembly

TABLE I

Isotope	Type of Beta decay	V/C	Observed L/R	Degree of polarisation P
Co^{60}	$\Delta J = 1$ No	0·57	1·38±0·02	−(1·00±0·02) V/C
Pr^{144}	$\Delta J = 0$ Yes $0^- \rightarrow 0^+$	0·57	1·27±0·02	−(0·86±0·02) V/C
Rb^{86}	$\Delta J = 2$ Yes	0·57	1·30±0·02	−(0·94±0·02) V/C

these experiments to depolarisation due to source thickness, thickness of the source backing, and slight deviation from the transverse nature of the beam. Tm^{170} which was used to test the instrument was a thicker source (about 2 mgm./cm.^{2}) and had a thicker backing (about 5 mgm./cm.^{2}). This resulted in a considerable depolarisation, $P = -0\cdot7\ V/C$. These depolarisation effects are being studied in detail.

SUMMARY

An experimental set up is described for converting longitudinal polarisation of beta particles to transverse polarisation and for determining the degree of polarisation, using the method of Mott scattering from a thin gold foil. Electron polarisation in the energy range 90 to 150 KeV can be studied. The degree of polarisation for beta particles of energy 110 KeV from Co^{60}, Pr^{144} and Rb^{86} has been determined and is seen to be equal to $-V/C$, within the limits of experimental error.

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