dominant in this transition. Thus, there is an apparent inconsistency between the experiments on the negatron decay of He^6 and the positron decays of Ne^{19} and A^{35}.

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Parity and Electron Polarization: Møller Scattering*

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Lee and Yang's proposal that parity may not be conserved in weak interactions,[1] and the subsequent experimental confirmation[2–4] require a careful and complete reinvestigation of beta decay. The measurement of the electron polarization for various electron and positron decays seems to be a valuable tool in this respect.

In a recent letter,[5] we reported on an experiment in which we first transformed the longitudinal polarization of electrons from Co^{60} into a transverse one by means of an electrostatic field and then used Mott scattering to determine the transverse polarization. Similar experiments have since been communicated by other groups.[6–8]

The methods based on Mott scattering possess two weak points: (1) these are not effective for positrons, and (2) the scattering in the analyzer foil introduces errors which are difficult to evaluate accurately. Hence we searched for another way of observing the electron polarization and we report here on a measurement using Møller scattering.[9,10] The cross section for Møller scattering depends strongly on the relative orientation of the spins of the incident and target electron.[11] The dependence is most pronounced for collisions where the electrons possess equal energies after the scattering. For electrons, the cross section for such scattering with the spins parallel, σ_+, is much smaller than that for the spins antiparallel, σ_-, at all energies. For positrons, the spin dependence is small at low energies and approaches that for electrons at high energies ($\sigma_+/\sigma_-\rightarrow\frac{1}{8}$).

Detection of one of the electrons only is not practical since Rutherford scattering is much stronger and masks the desired effect. Simultaneous observation of both electrons, however, allows one to pick out the desired Møller scattering events. The idea of the present experiment is thus to use two counters and to record coincidences, accepting only electrons in a defined energy range. Assuming that one selects electrons with about equal energies and that a fraction f of the electrons in the scatterer is polarized, one may write

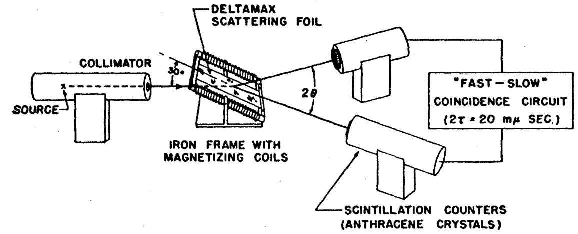

Fig. 1. Schematic drawing of the arrangement used to determine the longitudinal polarization of electrons by means of Møller scattering.

$$\delta\equiv2(C_p-C_a)/(C_p+C_a)=2f\cos\alpha\, P(1-\epsilon)/(1+\epsilon),$$

where C_a and C_p represent the number of coincidences when the electron momentum and the polarizing magnetic field in the scattering foil are antiparallel and parallel, respectively; α is the angle between the polarization in the foil and the direction of the incident beam; ϵ is the ratio σ_+/σ_-; and P is the polarization of the electrons from the source.

This method of observing the polarization is to a large extent free of the two restrictions mentioned above on Mott scattering. Positrons and electrons can be investigated. Plural scattering in the analyzer foil is less disturbing since two of the properties of both of the scattered electrons are selected, namely their energies and their angles. If one of the electrons suffers an excessive scattering, the event will not be recorded.

The experimental arrangement is shown schematically in Fig. 1. The scatterer consists of a magnetized Deltamax foil[12] having a thickness of 2.7 mg/cm^2 and an induction of 15 000 gauss ($f=0.055\pm0.004$) which is placed at an angle α of ±30 degrees with the electron beam. The electron collimator and the scatterer were placed in a helium atmosphere in order to reduce the undesired scattering in the air. As a check on the reality of the results with the Deltamax foil, an aluminum foil (5 mg/cm^2) was placed in the same field of seven oersteds and the coincidences were found to show no dependence on the direction of the magnetic field.

Some experimental results are summarized in Table I. From these data, the following conclusions can be drawn.

1. Møller scattering is well suited to measure the longitudinal polarization of electrons emitted in beta decay. In contrast to the conventional method,[5–8] the

TABLE I. Longitudinal electron polarization, determined by Møller scattering.

Nuclide and decay	Electron energy E_0, in Mev	$(v/c)_{Av}$	δ Deltamax scatterer	δ Aluminum scatterer	Polarization P
P^{32}	0.3 − 1.0	0.85	−0.064 ± 0.007		−0.85 ± 0.11
$1^+ \rightarrow 0^+$	0.8 − 1.6	0.94	−0.069 ± 0.010		−0.94 ± 0.16
e^-	0.3 − 1.0	0.85		−0.002 ± 0.009	⋯
Pr^{144}	0.4 − 1.1	0.86	−0.049 ± 0.013		−0.66 ± 0.18
$0^- \rightarrow 0^+$	1.2 − 3.0	0.97	−0.076 ± 0.017		−1.05 ± 0.25
e^-	0.4 − 1.1	0.86		+0.013 ± 0.008	⋯

longitudinal polarization does not have to be transformed, the experimental arrangement is extremely simple, and plural scattering in the analyzer foil is not critical.

2. The negative sign of the polarization of the electrons from P^{32} and Pr^{144} shows that they are emitted with their spin opposite to their momentum. This fact agrees with the earlier observations on electron emitters.[2,5–8]

3. The magnitude of the polarization is equal to v/c, within the limits of error of the present measurement. These limits can be reduced considerably by straightforward improvements in the method.

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[11] These cross sections have been calculated by A. Bincer and were kindly communicated to us by F. J. Dyson. If one denotes the scattering angle in the center-of-mass system by θ^*, and uses $x=\cos\theta^*$, $\beta=v/c$, the cross section ratio for *electrons* can be written as

$$\frac{\sigma_+}{\sigma_-}=\frac{2x^2+\beta^2(3x^2+x^4)+\beta^4(1+x^2)}{1+x^2+\beta^2(2+3x^2-x^4)+\beta^4(5-4x^2+x^4)}.$$

For the scattering of *positrons* by electrons, the corresponding equation is

$$\frac{\sigma_+}{\sigma_-}=\frac{1+6\beta^4x^2+\beta^6x^4+(1-\beta^2)[1-4\beta^2+\beta^4+2(4\beta^2-\beta^4)x+\beta^2x^2+2\beta^4x^3]}{8+(1-\beta^2)[-6-7\beta^2+\beta^4+6\beta^2(1-\beta^2)x-\beta^2(1-7\beta^2+\beta^4)x^2-2\beta^4(1-\beta^2)x^3-\beta^6x^4]}.$$

[12] Kindly supplied by Arnold Engineering Corporation, Marengo, Illinois.