Search for Pseudoscalar Interaction in $\frac{1}{2}+\rightarrow\frac{1}{2}-$ β-Decay Transition

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The longitudinal polarization of the electrons emitted by ${}_{81}Tl^{207}$ $(\frac{1}{2}+\rightarrow\frac{1}{2}-)$ was measured by double Coulomb scattering. Within the experimental error, a $-v/c$ polarization was obtained. In order to deduce the amount of pseudoscalar contributions, one must know the other nuclear matrix elements. They were taken from a theoretical shell-model calculation and a $j-j$ coupling single-particle model. Assuming $C_S=C_T=0$, two-component neutrino theory [which predicts opposite polarization in the case of (V,A) and P interactions], left-handed neutrino, and time-reversal invariance, as well as a surface distribution of the nuclear charge, one finds $|x|^2\leq 4.4\times 10^{-2}$ (if $C_P/C_A>0$), with $x=-i(C_P/C_A)[\int\beta\gamma_5/\int\boldsymbol{\sigma}\cdot\mathbf{r}]\rho$ (ρ being the nuclear radius).

RECENT experiments[1] suggest that in allowed β-decay transitions, the major contribution comes from (V,A) interactions, and little, if any, comes from (S,T) interactions. It is well known that the P interaction could be observed in first forbidden transitions with $\Delta J=0$, yes, where a mixture of (V,A) and P contributions of the same order of magnitude may be involved.

We tried to detect the P interaction in just such a case, assuming no contribution from (S,T) interactions. We used the fact that the longitudinal polarization of the electrons emitted in such a β-decay transition, could give information about the P interaction. Indeed, if the two-component neutrino theory is assumed, then the P interaction yields polarization opposite to that obtained from the (V,A) interactions.[2] As (V,A) gives negative helicity, for a $(V,A)-P$ mixture a polarization different from $-v/c$ is to be expected. The departure of the polarization from $-v/c$ could therefore be taken as an indication for the presence of the P interaction.

We studied ${}_{81}Tl^{207}(\frac{1}{2}+\rightarrow\frac{1}{2}-)$ [3] in radioactive equilibrium with ${}_{82}Pb^{211}$, both elements having roughly the same maximum energy (1.47 and 1.39 Mev, respectively).

Double Coulomb scattering[4] was used to measure the longitudinal polarization of the emitted electrons. The theoretical value was calculated taking into account geometrical corrections.[5] The longitudinal polarization for the equilibrium mixture of ${}_{81}Tl^{207}$ and ${}_{82}Pb^{211}$ was found to be

$$\mathcal{P}({}_{81}Tl^{207}+{}_{82}Pb^{211})=(0.98\pm0.13)(-v/c).$$

Assuming a $-v/c$ polarization for ${}_{82}Pb^{211}$, and knowing the proportion of the ${}_{81}Tl^{207}$ and ${}_{82}Pb^{211}$ electrons, we obtain:

$$\mathcal{P}({}_{81}Tl^{207})=(0.96\pm0.23)(-v/c).$$

As a check, we measured the longitudinal polarization of the electrons emitted by P^{32} (allowed transition). In exactly the same experimental conditions, we obtained:

$$\mathcal{P}(P^{32})=(0.97\pm0.14)(-v/c),$$

in agreement with the results obtained by other methods.[6]

In order to deduce the amount of pseudoscalar contributions to β decay, corresponding to our experimental results, we had to compare the experimental polarization with the theoretical one expected for ${}_{81}Tl^{202}\rightarrow{}_{82}Pb^{202}$. The nuclear matrix elements were taken from a theoretical shell-model calculation assuming a $j-j$ coupling single particle model. The Coulomb contribution to the final state potential has also been taken into account.[7,8] Then, from calculations performed with Lee-Whiting's formula for forbidden β-decay transitions,[9] and assuming: $C_S=C_T=0$, two-component neutrino theory, left-handed neutrino, and time-reversal invariance, as well as a surface distribution of the nuclear charge, one finds

$$|x|^2\leq 4.4\times 10^{-2} \quad \text{if } C_P/C_A>0,$$

$$|x|^2\leq 8.6\times 10^{-2} \quad \text{if } C_P/C_A<0,$$

with

$$x=-i\frac{C_P}{C_A}\frac{\int\beta\gamma_5}{\int\boldsymbol{\sigma}\cdot\mathbf{r}}\rho.$$

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[7] The author is indebted to Dr. M. E. Rose for drawing his attention to the great importance of the Coulomb contribution to the final state potential (when $n\rightarrow p+e+\bar{\nu}$), for high values of Z.

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Our results are in good agreement with those obtained for Pr^{144} and Ho^{166} ($0- \rightarrow 0+$, yes).[10]

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Calorimetric Determination of the Average Total Kinetic Energy of Fragments from Fission of U^{235} and U^{238} by 14-Mev Neutrons*

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The fission yields of Mo^{99} from 14-Mev neutron bombardments of U^{235} and U^{238} were found to be $(5.01\pm0.15)\%$ and $(5.86\pm0.16)\%$, respectively. The average total fragment kinetic energies released in fission of U^{235} and U^{238} were found to be 174 ± 4 and 175 ± 2 Mev, respectively.

I. INTRODUCTION

THE success achieved in previous calorimetric and radiochemical determinations of the fragment energy from fission of U^{235} by thermal neutrons[1] showed the feasibility of extending the measurements to fission induced by 14-Mev neutrons. Calculations based on the intensities of known sources of 14-Mev neutrons, together with consideration of experimental difficulties due to expected background effects, make it appear impractical to attempt the measurement by time-of-flight or pulse-height analysis techniques at this time.

II. EXPERIMENTAL

A. Fission Yields of Mo^{99}

The determination of the number of fissions that took place in a large sample of uranium was made by radiochemical analysis for Mo^{99}. Data needed to calculate the number of fissions from observed Mo^{99} activity are the fission yield of Mo^{99} under our experimental conditions, and the counting efficiency of our counter for Mo^{99} radiations. A measured amount of uranium was evaporated onto a 1-in.-diam 0.002-in.-thick platinum plate which was placed in a fission counter (Fig. 1). Several samples were prepared. The amount of uranium used varied from 25 to 100 micrograms. The uranium was confined to an area $\frac{3}{4}$ inch in diameter. In order to check the operation of the counter, the output of the fission-counter amplifier was fed simultaneously into six scaling units, each set to discriminate against pulses below a certain amplitude. The level of discrimination varied from scaler to scaler. The number of counts recorded in each scaler was plotted against the discrimination level of the scaler and the linear portion of the resulting curve extrapolated to zero discrimination level. The counter was considered to be operating satisfactorily when the extrapolated number of counts at zero discrimination was no more than 10% greater than the high-discrimination end of the linear portion of the curve.

The 14-Mev neutrons were produced by the reaction $H^3(d,n)He^4$ using a Cockcroft-Walton accelerator. The fission counter was clamped as close to the tritium target as possible to obtain maximum flux. The flux was monitored by counting the helium ions produced in the reaction. A further check on fission counter operation as well as reproducibility of position was accomplished by the measurement of the ratio of fission counts at zero discriminator bias per μg of uranium to helium ion counts for several different fission-counting samples. This ratio remained constant to 0.5% [see Eq. (4) below].

The amount of Mo^{99} produced in the fission-counting samples was too small to determine radiochemically. A larger sample of uranium metal was therefore placed directly under the fission-counting sample. This larger sample was $\frac{3}{4}$-in. in diameter and 0.001 in. thick, wrapped with two layers of 0.001-in.-thick 2*S* aluminum foil. The inner layer served to catch fission-fragment recoils, the outer layer to prevent contamination of the target packet with unwanted externally-produced activity. The uranium targets were about 1 in. away

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