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CIRCULAR POLARIZATION OF γ QUANTA FROM Ta^{181}

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Submitted 10 December 1966
ZhETF Pis'ma 5, No. 2, 73-75, 15 January 1967

Measurement of the circular polarization of the γ quanta emitted by unpolarized nuclei makes it possible to determine the admixture of weak nucleon-nucleon interaction in nuclear processes. A convenient object for research of this type is the 482-keV γ transition in Ta^{181}, which is excited in β decay of Hf^{181}. We have shown in an earlier paper [1] that the circular polarization of this transition is smaller than $\approx 2 \times 10^{-5}$. In this paper we report new measurements of the circular polarization of the Ta^{181} γ quanta with the aid of a procedure proposed in [2] and developed subsequently in [1] and [3].

The Hf^{181} source was obtained by irradiating in a neutron flux $\approx 10^{15}$ cm^{-2}sec^{-1} (in an SM-2 reactor) tablets of HfO_2 prepared from the separated isotope Hf^{180} (95% enrichment) and mixed with magnesium oxide. The use of the separated isotope makes it possible to eliminate the Hf^{175} admixture, which decays via K capture with emission of positively polarized internal bremsstrahlung. The activity of the Hf^{181} source at the start of the measurements was $\approx$500 Curie.

The experimental effect was determined by calculating $\delta = 2(J_1 - J_2)/(J_1 + J_2)$, where $J_{1,2}$ are the intensities of the registered γ quanta corresponding to opposite directions of polarimeter magnetization. The measurement results are given in Table 1.

The data indicate the presence of a certain effect $\delta = -(2.9 \pm 0.4) \times 10^{-7}$, which corresponds to a polarization $P = -6 \times 10^{-6}$. The measurements were made with lead absorbers of varying thickness (see [3]) and with an interval of 60 days between runs II and III. We see that, within the limit of statistical errors, the effect is independent of both absorber thickness and time. This excludes the possibility of the effect being due to bremsstrahlung in β decay of Hf^{181}, or due to any admixture of some β activity.

We used Sc^{46} and Bi^{82} as control sources of unpolarized γ quanta (unhindered E2 and E1 transitions). The results of measurements with these sources are also listed in Table 1. Other control experiments were carried out in the same manner as in [1] and [3].

The result agrees with our earlier paper [1] and refutes completely the result of Boehm and Kankeleit [4], who obtained $P = -(2.0 \pm 0.4) \times 10^{-4}$.

Table I

Source	Filter thickn. (mm)	δ	P
^{46}Sc	2	$+(0.5 \pm 0.3) \cdot 10^{-7}$	
^{82}Br			
I	2	$-(3.3 \pm 0.7) \cdot 10^{-7}$	With allowance for control expt. errors
^{181}Ta II	2	$-(2.9 \pm 0.65) \cdot 10^{-7}$	
III	2	$-(2.4 \pm 0.65) \cdot 10^{-7}$	$-(6 \pm 1.1) \cdot 10^{-6}$
Averaged with weight		$-(2.9 \pm 0.4) \cdot 10^{-7}$	$-(6 \pm 0.8) \cdot 10^{-6}$
^{46}Sc			
^{82}Br	2	$+(0.7 \pm 0.6) \cdot 10^{-7}$	

Table II

Source	$P = 2RF$	2R	F
Lu^{175}	$+(4 \pm 1) \cdot 10^{-5}$	50 - 200	$(8 - 2) \cdot 10^{-7}$
Ta^{181}	$-(6 \pm 1.1) \cdot 10^{-6}$	$+(15 \div 150)$	$-(4 - 0.4) \cdot 10^{-7}$

It is interesting to compare the Ta^{181} data with those for Lu^{175} [3] and the corresponding enhancement factors R (Table 2). If we assume Michel's hypothesis [5] that the factor F for mixing states with different parity, which characterizes the amplitude of the weak nucleon-nucleon interaction, does not change much from nucleus to nucleus and depends little on the structure of the levels between which the γ transition takes place, then it follows from Table 2 that F lies in the range $F = -(2 - 4) \times 10^{-7}$.

Of course, such an estimate is qualitative in nature, owing to the uncertainty in the limits of the enhancement factors R. The sign of F, given in Table 2, follows from the calculations of Wahlborn [6], who determined the sign of R for Ta^{181}. Unfortunately, nothing can be said concerning the sign of R for Lu^{175}.

The value of F estimated with the aid of universal weak interaction theory with conserved vector current [5] ($F \approx (5 - 8) \times 10^{-7}$) agrees qualitatively with our results. Our results agree also with those of [7].

In conclusion, the authors are deeply grateful to Professor D. M. Kaminker for continuous support and collaboration, and to V. A. Knyaz'kov and N. V. Porozov for participating in the construction of the apparatus and in the measurements. The authors are also greatly indebted to the crew of the SM-2 reactor for cooperating in the preparation of the Hf^{181} source.

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The corrected Table I follows:

Source	Filter thickn.	δ	P
^{46}Sc ^{82}Br	2 mm	$+(0,5\pm 0,3)\cdot 10^{-7}$	
^{181}Ta I	2 mm	$-(3,3\pm 0.7)\cdot 10^{-7}$	Polarization of Ta^{181} γ quanta with allowance for control experiment errors
II	1 mm	$-(2,9\pm 0,65)\cdot 10^{-7}$	
III	2 mm	$-(2,4\pm 0,65)\cdot 10^{-7}$	$-(6\pm 1,1)\cdot 10^{-6}$
Averaged with weight		$-(2.9\pm 0,4)\cdot 10^{-7}$	$-(6\pm 0.8)\cdot 10^{-6}$
^{46}Sc ^{82}Br	2 mm	$-(0,7\pm 0,6)\cdot 10^{-7}$	