tion velocity and with a ray velocity directed at an angle to the wave front. It is of interest to trace experimentally the variation of the effective velocity obtained from IMBS as a function of the angle given by the experimental geometry.

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SEARCH FOR PARITY NONCONSERVATION IN NUCLEAR GAMMA TRANSITIONS

V. M. Lobashov, V. A. Nazarenko, L. F. Saenko, and L. M. Smotritskii
A. F. Ioffe Physico-technical Institute, USSR Academy of Sciences
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Phenomena connected with weak nucleon-nucleon interaction were recently observed in gamma decays of nuclei. These include the asymmetry of photon emission upon capture of polarized neutrons by Cd^{113} (asymmetry 3.7×10^{-4}) [1] and circular polarization of the gamma quanta from Ta^{181} ($P_\gamma = 2 \times 10^{-4}$) [2].

In view of the great difficulty of experiments of this kind, refinement of the existing data and searches for new effects are most desirable.

The greatest difficulty in the measurement of small effects is a decrease in the statistical error within an acceptable duration of the experiment at the pulse-counting rates attainable with modern apparatus ($\sim 10^7$ counts/sec).

One of the authors of this article has proposed a method of measuring the circular polarization of gamma quanta, in which the statistical accuracy of the result is limited only by the γ-quantum source strength [3].

A feature of the method is that the integral detector current is recorded instead of counting individual pulses produced in the γ-quantum detector. A periodic change of the γ-quantum intensity upon reversal of magnetization of the polarimeter, in the case when polarization is present, is measured by a resonant device tuned to the magnetization-reversal frequency and making it possible to accumulate the signal. In this investigation we used this method to measure the circular polarization of the γ quanta emitted from Ta^{181} after the β decay of Hf^{181}.

The circular polarization was measured by the "forward scattering" method. The polarimeter switching frequency was 0.5 cps. The detector was a NaI(Tl) crystal with semiconductor surface-barrier counter (photodiode) which was insensitive to the action of the magnetic field, unlike a photomultiplier. The γ-quantum energy discrimination was attained by means of filters surrounding the detector.

The voltage on the photodiode load was amplified with a resonant amplifier tuned to 0.5 cps, and fed to a pendulum filter, comprising a pendulum with $Q \sim 1.2 \times 10^5$ and a period constant within 10^{-7}. The pendulum was tuned to the polarimeter switching frequency with accuracy $\sim 10^{-6}$.

The signal from the amplifier output was transformed with the aid of an electromagnetic system into mechanical forces which caused the pendulum to oscillate. The high Q of the pendulum made possible accumulation of the signal for several hours. The amplitude and phase of the pendulum oscillations relative to the instant of polarimeter switching was measured with a photoelectric system. Each measurement cycle began with the pendulum not oscillating and lasted for 6 hours. The amplitude and phase of the oscillations at the end of the cycle corresponded to some effective sinusoidal signal, averaged over the cycle and acting on the amplifier input. The results of the individual cycles could be added and subtracted vectorially. If $I_{1,2}$ is the γ-quantum intensity for different magnetization directions, then the

Table

Source and type of experiment	Number of cycles	Δ_{exp}	$\bar{\Delta}_{exp}$	$\bar{\Delta}_{calc}$	ΔU_{in}, V	$P_{\gamma\ exp}$
Sc^{46}, circ. polar.	6	$(0.3\pm0.6)\times10^{-6}$	$+(0.2 \pm 0.5)\times10^{-6}$	0	$(3\pm6)\times10^{-6}$	
	9	$(0\ \pm0.7)\times10^{-6}$	$(0\ \pm 0.6)\times10^{-6}$	0	$(0\pm5)\times10^{-6}$	
Double scattering	1	1.8×10^{-3}	$+1.8 \times 10^{-3}$	$+2.2 \times 10^{-3}$	$6. \times 10^{-6}$	
	1	1.9×10^{-3}	-1.9×10^{-3}	-2.2×10^{-3}	6.5×10^{-6}	
	1	2.1×10^{-3}	$+2.1 \times 10^{-3}$	$+2.2 \times 10^{-3}$	5.5×10^{-6}	$\pm4.0 \times 10^{-2}$
	1	2.0×10^{-3}	-2.0×10^{-3}	-2.2×10^{-3}	5.2×10^{-6}	
Au^{198}, foil of Au mixed with Mg (wt. ratio 1:5)	4	$(4.8\pm0.1)\times10^{-5}$	$-(4.8 \pm 0.1)\times10^{-5}$	$-(2\pm6)\times10^{-5}$		-1.1×10^{-3}
	4	$(2.2\pm0.1)\times10^{-5}$	$-(2.2 \pm 0.1)\times10^{-5}$	-		-5×10^{-4}
Hf^{181} I. NaI(Tl) 40 x 40 mm no light pipe	14	$(0.5\pm0.6)\times10^{-6}$	$(0\ \pm 0.5)\times10^{-6}$			$(0\ \pm1.0)\times10^{-5}$
II. NaI(Tl) 50 x 70 mm no light pipe	3	$(2\ \pm1.5)\times10^{-6}$	$+(1.5 \pm 1.2)\times10^{-6}$			$+(3\ \pm2.4)\times10^{-5}$
III. Same, with light pipe	3	$(0.4\pm1\ )\times10^{-6}$	$-(0.2 \pm 0.8)\times10^{-6}$			$-(0.4\pm1.6)\times10^{-5}$
IV. Same, gain of ckt. measured	3	$(0.2\pm1\ )\times10^{-6}$	$-(0.1 \pm 0.8)\times10^{-6}$			$-(0.2\pm1.6)\times10^{-5}$
Hf^{181} weighted mean			$(0.07\pm0.35)\times10^{-6}$			$(0.15\pm0.7)\times10^{-5}$

equivalent sinusoidal voltage at the amplifier input is

$$(\Delta/2)U_{in}\sin(\omega t+\varphi),\qquad \Delta = 1.2\,\delta;\qquad \delta = 2\,(I_1 - I_2)/(I_1 + I_2)$$

(U_{in} is the voltage produced by the photocurrent on the photodiode load). The correspondence between the amplitude and phase of the pendulum oscillations and the signal at the amplifier output was determined experimentally. The phase of the oscillation corresponding to a definite polarization was likewise determined experimentally. The table lists the values of $\bar{\Delta} = \Delta\cos(\varphi_1 - \varphi_2)$, where φ_1 is the phase of the investigated signal and φ_2 the phase of the signal corresponding to positive polarization. $\bar{\Delta}$ is the effect connected with the polarization, and $P_\gamma = \bar{\Delta}/f$, where $f = 5 \times 10^{-2}$ for 500-keV γ quanta.

We investigated the influence of different causes of false signals. These include inductive pickup in the circuit from the alternating field of the polarimeter and the magnetostriction change in polarimeter dimensions during the passage of the magnetization through zero. The first effect was reduced to $\Delta = (0.5 - 1) \times 10^{-6}$ by thorough screening, and a corresponding correction was introduced in each result. The second effect appeared only in the presence of switching asymmetry and was reduced to $\Delta < 10^{-7}$.

A check on the elimination of these and also other false effects was carried out with a Sc^{46} source having γ quanta of multipolarity E2, i.e., practically unpolarized. The source strength was 100 Ci.

The results are listed in the table. The absence of false effects is demonstrated. The measurement error was determined from the scatter of the experimental results [3]. The γ quanta with known magnitude and sign of polarization were obtained from Sc^{46} after scattering in a polarimeter similar to that used for the measurements and magnetized in one direction during the entire time (double scattering), and also bremsstrahlung γ quanta from β electrons of Au^{198}, obtained as an admixture to the ground-state 411-keV E2 transition.

For double scattering, the estimate of $\bar{\Delta}$ was made in accord with [4]. For the bremsstrahlung of the Au^{198} the estimates were made in accord with the data of [5]. The results of the experiments are listed in the table and show agreement with the calculations. The Hf^{181} source with 200 Ci activity was prepared in the form of tablets of HfO_2 mixed with MgO (hafnium in the form of a natural isotope mixture), so as to reduce the contribution of the bremsstrahlung γ quanta from the Hf^{181} β electrons. Owing to the energy discrimination of the γ quanta, only the 482-keV γ line was registered in practice (transition (M1 + E2) $7/2^+ \to 5/2^+$).

The results of the measurements are listed in the table. The errors are obtained from the scatter of the individual measurements. All runs show, within the limits of statistical error, absence of noticeable circular polarization of the γ quanta of the 482-keV transition. In individual runs, the experimental conditions were varied somewhat, as indicated in the table. Different photodiodes were used in runs III - IV and I - II. An interval of 40 days elapsed between runs III and II. Taking into account the errors of all the experiments, including the control experiments, we can estimate the upper limit of the polarization of the 482-keV γ quanta in Ta^{181}: $P_\gamma \leq 2 \times 10^{-5}$. Account was taken here of the possible partial compensation of the γ-quantum polarization by the admixture of the 343-keV (M1) γ transition (intensity 5%) from the Hf^{175} obtained when the natural isotope mixture is irradiated in a reactor.

The contribution of the bremsstrahlung from the β electrons was determined more precisely by measuring the polarization of γ quanta from a source of Lu^{177}, which has a β spectrum with end-point energy 490 keV and relatively soft γ quanta (208 keV), suppressed with filters. The measurements were made with a source of 4000 Ci activity, prepared in the same manner as the Hf^{181} source. Negative polarization was observed, which when recalculated in terms of the activity of the Hf^{181} source provides an estimate of the contribution made to the polarization by the bremsstrahlung ($P_\gamma = -0.5 \times 10^{-5}$).

Thus, our results do not agree with the data of Boehm and Kankeleit [2], who obtained a value $P_\gamma = -(2.0 \pm 0.4) \times 10^{-4}$ for the polarization of the γ quanta of the 482-keV transition in Ta^{181}. It is quite difficult to determine the causes of the discrepancy, and we can only emphasize once more that the measurement of so small a polarization by means of the usual procedure is an extremely difficult task.

According to calculations by Wahlborn [6], the amplification factor for this transition lies in the range $30 \leq R \leq 110$, so that an estimate of the mixing factor F from our data will yield $F < (6 - 2) \times 10^{-7}$, which does not contradict the estimate given in [7] (8×10^{-7}), taking into account the highly approximate nature of such estimates.

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THE MOSSBAUER EFFECT ON Dy^{161} IMPURITY NUCLEI IN MATALLIC GADOLINIUM

I. I. Lukashevich, V. V. Sklyarevskii, K. P. Aleshin, B. N. Samoilov, E. P. Stepanov, and N. I. Filippov

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Irradiation of metallic gadolinium in a reactor (97% Gd^{160}) gives rise to the reaction $Gd^{160}(n\ \gamma)Gd^{161} \xrightarrow{3.7\ \text{min}} Tb^{161}$, and the decay of the Tb^{161} causes emission of γ rays of