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Compton polarimetry detection of small circularly and linearly polarized impurities in Mössbauer 8.4 keV (3/2-1/2) M1 γ-transition of ^{169}Tm

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Abstract The arrangement of an experiment to detect the $P-$odd and $P, T-$odd polarized part of the Mössbauer ($^{+}3/2$–$^{+}1/2$) gamma transition of a deformed ^{169}Tm nucleus with an energy of 8.4 keV by Compton polarimetry is discussed. Tm_2O_3 single crystal with a quadrupolarly split Mössbauer spectrum is proposed as a resonance polarizer. A Be-scatterer-based Compton polarimeter and a synchronously detecting system will be used to measure the P-odd circular polarization $P_C$and P, T-odd linear polarization P_L.The expected accuracy of measuring the relative magnitude of the P, T-odd contribution is about 1% of the magnitude of usual weak nucleon–nucleon interaction.

Keywords Mössbauer spectroscopy · ^{169}Tm nucleus · Quadrupole interaction · Compton polarimetry · Faraday rotation · P-odd polarization · Synchronous detector

1 Introduction

The demonstration of the combined *CP*-nonconservation in the neutral kaons decay remains the most reliable its experimental confirmation and a pulse to search for it in other processes, including modern attempts to reveal an electric dipole moment (EDM) of nucleons. At the same time, assuming the validity of *CPT*-theorem leads to equivalence of *CP*- and T-violence. Therefore, direct experiments to find the P, T-odd part of ordinary weak

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nucleon–nucleon (*NN*) interaction in low energy (Mössbauer) gamma-transitions also can serve as an addition to searching for the EDM of nucleons [1, 2]. They based on the fact that for a regular M1 (E1) gamma-transition the P, T-odd part of *NN*-interaction, $V^{P,T}$,in a nuclear hamiltonian will produce an irregular E1 (M1) one characterized by an imaginary matrix element. It results in a small linear polarization, P_L,of radiation, which can be revealed at passing it through a resonance medium, containing oriented Mössbauer nuclei and registered by a Compton polarimeter [3].

On the other hand, P-odd T-even part of *NN*-interaction, V^P,for a regular M1 (E1) transition will produce an irregular E1 (M1) transition with a real matrix element. In this case, two types of P-odd effects appear due to mixing of different multipoles: a) an asymmetry of gamma-quanta emission in relative to the direction of a nuclear spin and b) a circular polarization, P_C,of radiation from an unpolarized (polycrystalline) source. Such effects were observed experimentally: a) depending on the direction of the magnetic field on nuclei for the Mössbauer ($^+3/2$–$^+1/2$) M1 transitions in ^{119}Sn and ^{57}Fe [4], and b) for the regular Mössbauer ($^-5/2$–$^+5/2$) E1 transitions in deformed ^{237}Np [5] and ^{161}Dy nuclei [6] the P_C was measured by a Compton polarimeter.

An experiment to put the upper limit on the simultaneous P- and T-violation has already been set up for the Mössbauer ($^+3/2$–$^+1/2$) M1 gamma-transition in ^{119}Sn nucleus with E = 23.8 keV, in which the suggestion to use the quadrupole splitting of the ^{119}Sn excited state for its nuclear polarizing and a Compton polarimeter of an original design for the polarization measuring was proposed for the first time in [3] where was obtained an estimation for the ratio $< V^{P,T} > / < V^P >=$ -(1.6± 4.1)$\cdot 10^{-2}$. Below, we will discuss the formulation of a similar experiment for the Mössbauer ($^+3/2$–$^+1/2$) M1 transition of a deformed ^{169}Tm nucleus with an energy of 8.4 keV by the gamma-optics technique. Earlier, the search for P- and P,T-odd effects in this nucleus was not performed.

2 Calculation of the *P,T*- and *P*-odd polarizations

The general formalism of calculating the P-odd polarization and the experimental setup also described in [3]. Here we present concrete simulating calculations for the case of the thulium nucleus. A scheme of the experiment is following. Unpolarized radiation from excited thulium nuclei passes through a single crystal, containing thulium nuclei in a nonuniform electric field, the hyperfine doublet structure of which is determined only by quadrupole interaction. We propose using $^{169}ErF_3$ compound as the source with a half-life period of 9.4 days. A thulium oxide Tm_2O_3 single crystal will be used as the filter-polarizer. According to [7], the emission Mössbauer spectrum of thulium in the polycrystalline source is the doublet with $\Delta_0 = 2.2(2)$ cm/s. The Mössbauer spectrum of thulium oxide is a superposition of a singlet and doublet with the isomer shift $\delta = 0.0(2)$ cm/s respective to the $^{169}ErF_3$ source, and the quadrupole splitting $\Delta_1 = 3.3(2)$ cm/s, comparable in magnitude to the minimal experimental line-width $\Gamma = 1.8$ cm/s [8]. Both spectra were simulated with the formula (1) and are shown in Fig. 1a,b, correspondingly:

$$\rho(v, x) = \frac{1}{2} \cdot \left(\frac{1}{x - \frac{E_\gamma}{\frac{\Gamma}{2} \cdot c} \left(v - \frac{\Delta_0}{2} \right)^2 + 1} + \frac{1}{x - \frac{E_\gamma}{\frac{\Gamma}{2} \cdot c} \left(v + \frac{\Delta_0}{2} \right)^2 + 1} \right), \tag{1}$$

where $E_\gamma = 8.4$ keV, v – the source velocity, x - the deviation from the resonance in $\Gamma/2$ units.

The transmission Mössbauer spectrum, S_{pol},of the monocrystalline thulium oxide of thickness $t = f\sigma_0 n$ (σ_0 - is the resonance cross section in cm^2/atom, n - thickness in atom/cm^2) was simulated, using the convolution (1) with the kernel $E(t, x, \theta)$ (Fig. 1c):

$$E(t,x,\theta) = \left[\exp\left(-\sum \frac{\frac{t}{2}}{[\overline{x_i}(x)]^2+1} I_p^{(i)}(\theta)\right)\right] \cdot \left[ch\left(\sum \frac{\frac{t}{2} P_l^{(i)}}{[\overline{x_i}(x)]^2+1}\right)\right], \text{ where } \sin^2\theta = \frac{2}{3},$$
$$I_p^1 = \frac{3}{8}\left(2-\sin^2\theta\right), I_p^2 = 1, I_p^1 = \frac{3}{8}\left(2+3\sin^2\theta\right), P_l^1 = \frac{3}{8}\sin^2\theta, P_l^2 = 0, P_l^3 = -\frac{3}{8}\sin^2\theta,$$
$$\begin{cases} \overline{x}_1(x) = x + \frac{\Delta_1}{\Gamma} \\ \overline{x}_2(x) = x \\ \overline{x}_3(x) = x - \frac{\Delta_1}{\Gamma} \end{cases} \tag{2}$$

$$S_{pol}(v,t,\theta) = f \cdot \left\{1 - \frac{1}{\pi}\int_{-\infty}^{+\infty} \rho(v,x)E(t,x,\theta)dx\right\}. \tag{3}$$

The quadrupole interaction provides an additional opportunity of measuring the P-odd circular polarization $P_C$in Mössbauer transitions. Since the falling on a crystal radiation from a source is slightly polarized owing to $P-$violation, there can appear a certain P-odd Faraday rotation F_1 after the crystal because of a dichroism phenomenon. Corresponding expression is [3] (Fig. 1e):

$$\begin{aligned} F_1 &= \frac{P_c}{\pi}\int_{-\infty}^{\infty} \rho(x,v) \cdot \left(\sin\left\{\frac{\frac{t}{8}\cdot\overline{x_1}(x)}{[\overline{x_1}(x)]^2+1} - \frac{\frac{t}{8}\cdot\overline{x_3}(x)}{[\overline{x_3}(x)]^2+1}\right\}\right) \\ &\times \left(\exp\left\{-\frac{t}{2}\sum_i \frac{I_p^i(\theta)}{[\overline{x_i}(x)]^2+1}\right\}\right) dx, \; P_c = -2R, \end{aligned} \tag{4}$$

where $R$is obtained by definition

$$ImR = 2\frac{\langle V^{P,T}\rangle}{\langle V_0\rangle} = -\frac{\langle V^{P,T}\rangle}{\langle V^P\rangle} P_c.$$

For the unpolarized part of radiation there appears another ("classical") P-odd Faraday rotation. Due to the P-violation the linear-polarization sensitivity of absorption lines involves an additional term IP_C,where I - the intensity of a line. When the first layer of a filter partially polarizes the incident radiation, the following one then induces the dichroic Faraday rotation F_2 [3] (Fig. 1f):

$$\begin{aligned} F_2 &= \frac{1}{\pi}\int_{-\infty}^{\infty} \rho(x,v) \cdot \left(ch\left\{\frac{t}{2}B_L\right\} - \cos\left\{\frac{t}{2}A_L\right\}\right) \cdot \left(\exp\left\{-\frac{t}{2}\sum_i \frac{I_p^i(\theta)}{[\overline{x_i}(x)]^2+1}\right\}\right) \\ &\times \left(\frac{A_c B_L - A_L B_c}{(A_L)^2 + (B_L)^2}\right) dx, \end{aligned} \tag{5}$$

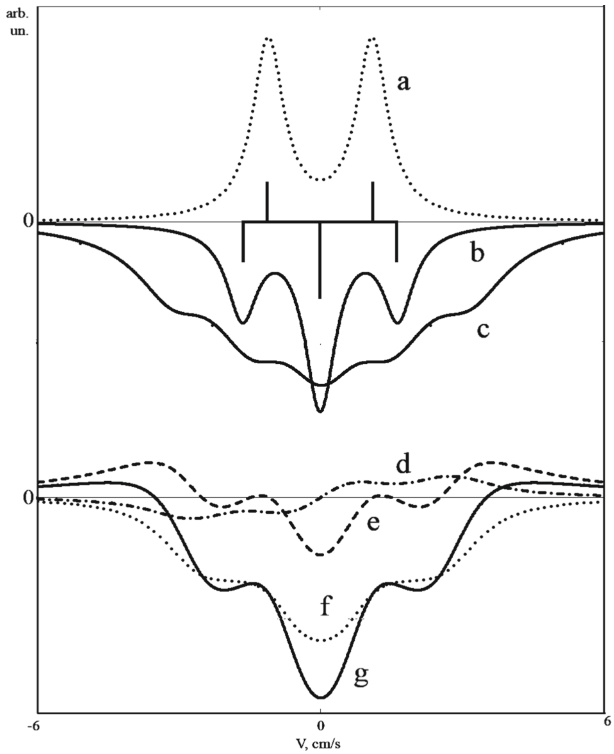

Fig. 1 Calculated velocity dependence of the source Mössbauer emission spectrum (**a**), the thulium oxide spectrum with a single line source (**b**), the thulium oxide transmission spectrum with the $^{169}ErF_3$ source (**c**), the linear polarization P_L (**d**), the Faraday rotation F_1 due to a dichroism phenomenon (**e**), the "classical" Faraday rotation F_2 (**f**) and total P-odd Faraday rotation $F_S = F_1 + F_2$ proportional to the circular P-odd polarization P_C (**g**)

where

$$
\begin{aligned}
A_L &= \frac{t}{8}\left(\frac{\overline{x_1}(x)}{[\overline{x_1}(x)]^2+1} - \frac{\overline{x_3}(x)}{[\overline{x_3}(x)]^2+1}\right),\\
B_L &= \frac{t}{8}\left(\frac{1)}{[\overline{x_1}(x)]^2+1} - \frac{1}{[\overline{x_3}(x)]^2+1}\right),\\
A_c &= R\frac{t}{2}\left(\frac{\overline{x_1}(x)}{[\overline{x_1}(x)]^2+1} + \frac{2\cdot\overline{x_2}(x)}{[\overline{x_2}(x)]^2+1} + \frac{\overline{x_3}(x)}{[\overline{x_3}(x)]^2+1}\right),\\
B_c &= R\frac{t}{2}\left(\frac{1}{[\overline{x_1}(x)]^2+1} + \frac{2}{[\overline{x_2}(x)]^2+1} + \frac{1}{[\overline{x_3}(x)]^2+1}\right).
\end{aligned}
$$

The sum linear polarization, F_S,due to the total Faraday rotation is $F_S = F_1 + F_2$ (Fig. 1g).

According to theoretical considerations, the maximum magnitude of the P, T-odd polarization must then be observed at an angle of 45 degrees to the beam–crystal axis reference plane (**nk**) [3]. Corresponding velocity spectrum, S, of P, T – odd P_L transmitted by the polarizer (Fig. 1d):

$$S = \frac{1}{\pi} \int_{-\infty}^{\infty} \rho(x, v) \cdot \left(\exp \left\{ -\frac{t}{2} \sum_i \frac{I_p^i(\theta)}{[\overline{x_i}(x)]^2 + 1} \right\} \right) (sh\,\{B_L\})\, dx. \tag{6}$$

3 Method of synchronous detecting

The most resultant data in searching for effects of deviation from the fundamental laws (violations of P-, T- and CP- invariance) in nuclear NN interactions were obtained in the low-energy physics. Measuring the degree of the circular polarization of γ-radiation or the asymmetry of an emission of quanta from polarized nuclei and also receiving the record lowest upper level on the CP- violation was obtained by Mössbauer and Compton polarimetry [3]. Because of used detection method was not described earlier in [3–6], below is a consideration of this question.

In our work, the presence of polarized components in the transmitted radiation will be revealed using a Compton polarimeter, consisting of a Be-scatterer and a system of four scintillation detectors. The detectors are arranged horizontally at right angles both to each other and to the vertical beam direction **k**. The reference plane is oriented at an angle of 45 degrees to each pair of detectors (D1, D3) and (D2, D4) arranged opposite one another. We here turn from a pulsed technique of registering events, which gives omissions in counting that limits either the speed of getting statistics or accuracy of measurement, and move to an integral (current) method of synchronous detecting.

The integral method makes it necessary to separate the signal, which is a result of averaging over a large number of registrations of particles. Statistical fluctuations of the source intensity will lead to random signal deviations from its mean value and create interference that additively superimposed on the received signal and will be perceived as a noise by the recording device. The average value or the constant component of it is obviously equal to zero and its dispersion, σ^2, is the noise power.

In order to study the abilities of the detecting system let us treat the properties of the synchronous detector containing the integrating RC-circuit at the output and representing the parametrical circuit which is controlled by sinusoidal voltage (with the frequency Ω) and performs an ideal operation of multiplication of input and control signals. Thus, if the signal of the $sin\omega t$-type is present at the input then voltage at the input of a passive integrator (RC-circuit) will be equal to:

$$V_M = \frac{1}{2}\cos(\omega - \Omega)t - \frac{1}{2}\cos(\omega + \Omega)t, \tag{7}$$

and complex amplitudes of the signal at the integrator output can be written in the form:

$$A_+ = \frac{1}{2\,[1 + j(\omega + \Omega)\tau]}, A_- = \frac{1}{2\,[1 + j(\omega - \Omega)\tau]},$$

where $\tau = RC$ – is the integration constant.

The selectivity properties of this scheme can be shown in the assumption $\omega \approx \Omega$ when the coefficient of its transmission is approximately equal to

$$|K| \approx \frac{1}{2} \frac{1/\Omega\tau}{\sqrt{(1 - \omega/\Omega)^2 + 1/(\Omega\tau)^2}}.$$

This equation differs from the transmission coefficient of oscillatory circuit with the quality

$$Q = \Omega \frac{\tau}{2}$$

only by the factor

$$\frac{1}{\omega \Omega}.$$

If in the present circuit we use an active integrator in the operational amplifier (as it has been done in the detecting tracts) then in (7) we must substitute $\Omega\omega$ for $K_{oa}\Omega\omega$,where K_{oa} is amplification coefficient of the operational amplifier with the disconnected feedback, usually reaching the value of 10^5-10^6. In this case selectivity of the signal with the frequency $\omega = \Omega$becomes rather high. Besides, the application of the active integrator by $1+K_{oa}$ times increases operating time in the linear regime (at integration of constant voltage).

Let us determine the ratio signal/noise at the output of the considered integrating synchronous detector, if at the section input the valid signal is modulated with the frequency Ω and the noise is present. Its dispersion at the synchronous detector output is determined as:

$$\sigma^2 = \frac{T_s}{\tau} \int_{-\infty}^{\infty} \rho(\omega) \cdot |K(\omega)|^2 d\omega,$$

where T_s is the time of the signal accumulation, $\rho(\omega)$ the spectral density of noise, $K(\omega)$ the coefficient of the circuit transmission. The real noise, which was at the circuit input, represents random sequence of pulses, which appear during detecting of photons. Spectral density of such a noise is constant at frequency

$$\frac{N}{2\pi},$$

where N – is the average number of pulses per second and is equal to

$$\frac{a^2 N}{2\pi}$$

a is the pulses' amplitude, i.e. the signal from statistical fluctuations is a flat random noise.

Noticing, that

$$|K(\omega)|^2 = |A_+(\omega)|^2 + |A_-(\omega)|^2,$$

after integration of (7) we obtain

$$\sigma^2 = \frac{a^2 N T_s}{4\tau^2}.$$

The magnitude of the valid signal at the output is

$$s_{out} = \frac{s_{in} a N T_s}{2\tau}. \tag{8}$$

Then for the considered circuit the ratio signal/noise equals to $s_{in}\sqrt{NT_s}$. Really this theoretical limit is not reached due to non-ideal characteristics of the device. Therefore, in practice the synchronous detecting with key mode of operation and the step character of input signal is often used. As the Fourier series expansion of the jump function has the form

$$\frac{4}{\pi} \sum_{n=0}^{\infty} \frac{\sin(2n+1)\Omega t}{2n+1},$$

then additional new (odd) harmonics will be subjected to the synchronous detection. The frequency response of the filter will already contain a number of bands with maxima at 3Ω, 5Ω etc. harmonics. The widths of these bands are determined only by the parameters of *RC*-circuit and have the previous value. The noise intensity at the detector output is multiplied by the amount $\sum_{n=0}^{\infty} \frac{1}{(2n+1)^2} = \frac{\pi^2}{8}$ and it becomes equal to

$$\sigma_{out}^2 = \frac{\pi^{2a} a^2 N T_s}{32\tau^2}.$$

A Fourier expansion of the input step signal will cause that all the odd harmonics of the input signal will also be subject to synchronous detection. Then formula (8) for the quantity of the useful output signal is modified as follows

$$\frac{S_{in} a T_s N}{2\tau} \cdot \frac{4}{\pi} \cdot \sum_{n=0}^{\infty} \frac{1}{(2n+1)^2} = \frac{S_{in} a T_s N \pi}{4\tau},$$

so the signal/noise ratio becomes

$$S_{in} \frac{\sqrt{N T_s}}{2},$$

that is twice worse than for the "ideal" method of the synchronous detection. Note, that at the counting method (e.g. using a pair of recounting circuits) the ratio signal/statistical error is equal to

$$S_{in} \sqrt{\frac{N T_s}{2}},$$

i.e. in $\sqrt{2}$ times less than for the key method of s synchronous accumulation. Increased accuracy in this method is achieved by the possibility of fixing the center of gravity of the signal.

In addition, this modification of synchronous detection allows carrying out two-dimensional analysis of the signal. If the signal is represented by a vector **A** with constant amplitude A and a phase ψ_0, the normal noise is a vector $\boldsymbol{R}$ with the Rayleigh distribution then R value recorded experimentally obeys the distribution:

$$\varpi(R) dR = I_0 \left(\frac{RA}{\sigma^2} \right) \cdot \exp\left[-\frac{R^2 + A}{2\sigma^2} \right] \cdot \frac{R dR}{\sigma^2}, \text{ (} I_0 \text{ is the Bessel function),}$$

which is the Rice distribution or generalized Rayleigh one [9].

An average square of R is equal: $R^2 = A^2 + 2\sigma^2$. Nevertheless, these slow changes of signal contain noticeable Fourier-components, hitting the band of the section transmission equal to ∼10 Hz. Thus, the source decay exponent $I_0 e^{-\lambda t}$ has the spectrum:

$$\rho(\omega) = I_0 \frac{2}{\pi} \frac{\lambda}{\omega^2 + \lambda^2}.$$

During the time $T_s = 2nT$ (T is the half-period of modulation) only due to exponential decrease of the "constant" component of the detecting signal the voltage in the integrator will be accumulated:

$$\frac{\Delta I}{I_0} = \frac{\lambda T}{2}(1 - e^{-2\lambda n T}) \to \frac{\lambda T}{2}, \text{ at, } n \to \infty.$$

This false signal is unimportant, if the signal modulation is determined, for example, by changing the sign of the relative velocity in the Mössbauer experiment where typically T

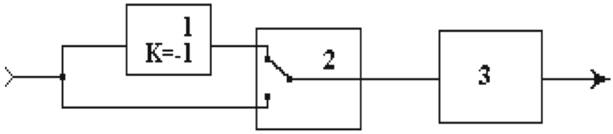

Fig. 2 Scheme of the synchronous detector with a key mode of operation: 1 - inverter, 2 - key, 3-integrator

$\sim$0.1 s and the decay constant $\lambda \sim 10^{-7}$ - 10^{-6}s^{-1}. However, in an experiment, including much longer variable signal, for example, reversing the sign of the magnetic field, this effect must be taken into account. The suppression of the effect associated with the decrease in the intensity of a radioactive source can be achieved by using the following so-called scheme of "octaves": + - - + − ++ -. . . where the signs + and – correspond to changing of the signs of the field direction. When the number of "octaves" is n, the relative false signal due to the source decay has a value of:

$$\frac{\Delta I}{I} = \frac{8(\lambda\Gamma)^4}{1 - e^{-8nT}} \to 8(\lambda T)^4, (n \to \infty)$$

and will be mostly suppressed.

During the measurements the detector signal is registered with an electrometric amplifier that transforms the current into the voltage signal, I. In one set of experiments, the integrator during the accumulation time $T_a = nT$ records the signal ΔI, its corresponding relative signal being

$$r_i = \frac{\Delta I}{I}.$$

If the experiment includes k sets of such accumulation intervals, the usual statistical treatment of the storage system reading gives the mean value

$$\overline{r} = \frac{\sum r_i}{k}$$

and its dispersion is

$$\sigma(r) = \left[\frac{(r_i - \overline{r})^2}{k\,(k-1)}\right]^{\frac{1}{2}}.$$

A scheme of a part of a synchronous detecting tract with a key mode of operation is shown in Fig. 2. The signal from a linear amplifier through an *RC*-circuit supplies to an inverter (1) and to a key (2) operated by pulses of a modulator (driver) synchronously with changing of an effect sign, and finally to an active storage integrator (3). The sought and reference signals are separated from the statistical noise using the law of the periodic variation of the sought signal specified by a vibrator, moving the Mössbauer source with a frequency of $\sim$15 Hz, and then are stored in different memory cells. In our experiment, the signals from four detectors are combined using a special programmable unit according to the following logic scheme: the difference between signals of pairs detectors (D2 + D4)–(D1 + D3) is a doubled $P-$odd or P, T-odd effect, while the same between pairs (D1 + D2)–(D3 + D4) and (D1 + D4)–(D2 + D3) are reference zero channels.

4 Discussion

The suggested technique to find $P-$ and P, T-violating effects in low-energy Mössbauer transitions compared to that normally applied to measure these quantities in nuclei (e.g., the

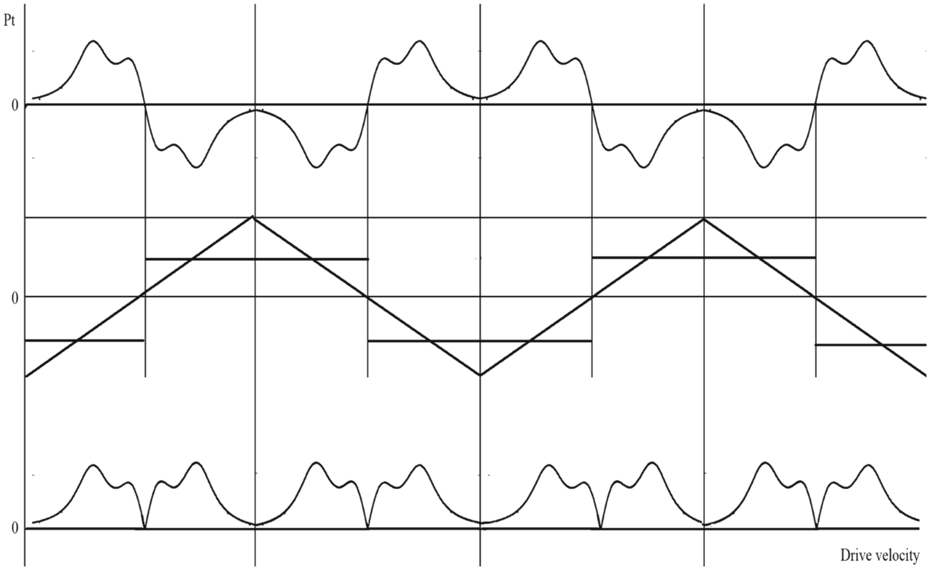

Fig. 3 Time-synchronous diagrams of the periodic modulation of the calculated linear polarization P_L (*top*), respective to the drive velocity sawtooth and synchronous meander pulses (*middle*), operating the state of the inverter, and the synchronously-detected signal after the key (2) (*bottom*)

polarized neutrons scattering) has a number of advantages. First, this procedure allows us to determine exactly the parameters of levels and nuclear polarizations using well-known hyperfine structure components, offering the opportunity to move away from the complex and expensive cryogenic ultralow-temperature equipment. Second, it provides a high aperture ratio, compared to ‘conventional procedures based on coincidences. Third, applying the experiment's geometry to the Mössbauer absorption variant completely eliminates the problem of false violation effects, arising from the interaction in the final state in the emission and scattering variants, which also limits the accuracy of traditional methods at the level of 10^{-3}.

Comparing velocity dependences of the linear polarization P_L (Fig. 1d) and circular polarizationP_C (Fig. 1g) shows that P_L is an odd and P_C is an even function of v that allows separating both signals in one and the same experiment. Namely, in order to extract the P_L-signal we must change the state of the key (2) (Fig. 2) when $v = 0$ (see Fig. 3 where shown time-synchronous diagrams of the periodic modulation of the P_L-signal). For the P_C-signal, we must do this when v = max value and simultaneously twice increase the modulation period, operating the key (2) (see Fig. 4 where shown time-synchronous diagrams of the periodic modulation of the $F_S \sim P_C$-signal).

Testing measurements with this detecting set-up during the experiment on measuring P_C and P_L in ^{119}Sn nucleus showed the experimental sensitivity magnitude to the P,T-odd effect better than $3 \cdot 10^{-5}$ [3]. The case of the Tm_2O_3 crystal in relation to the ratio between the linewidth and quadrupole splitting is similar to that of the SnS one [3] and promises the sensitivity at least at the level of 10^{-4}. Note, that the authors of [10] using the method of synchronous detection with reversing of the sign of the magnetic field direction gave the upper limit on the degree of T-invariance violation in the Mössbauer ($^+1/2$–$^+3/2$) mixed (M1+E2) transition of ^{197}Au with an energy of 77 keV at the level of $7 \cdot 10^{-4}$, while in a

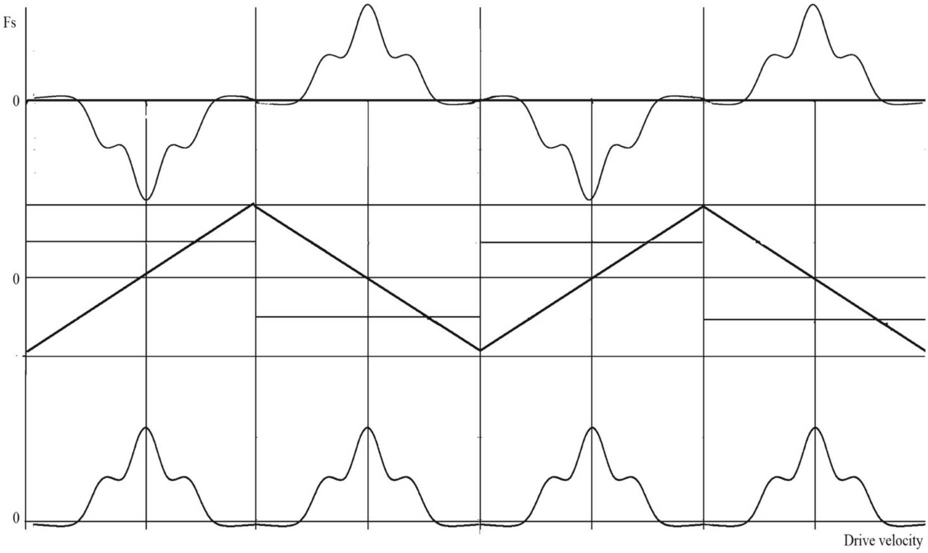

Fig. 4 Time-synchronous diagrams of the periodic modulation of the calculated F_S, which is proportional to the circular polarization P_C (*top*), respective to the drive velocity sawtooth and synchronous meander pulses (*middle*), operating the state of the inverter, and the synchronously-detected signal after the key (2) (*bottom*)

recent experiment on the similar ($^+$1/2–$^+$3/2) mixed (M1+E2) transition with an energy of 67 keV in ^{171}Yb this limit was brought to the level of $1\cdot 10^{-4}$ [11].

As for the effect of P-parity violation, the most systematic measurements have been performed using Mössbauer and Compton polarimetry and also the synchronous detection technique for gamma-transitions containing regular M1 multipoles in the almost spherical nuclei ^{57}Fe, ^{119}Sn, and ^{197}Au [3, 4]. In summary, the P_C values obtained for all of these nuclei have one and the same negative sign and comparable magnitudes in the range of -(1 – 9)$\cdot 10^{-4}$. The latter value has been also measured for E1 transitions between nuclear states with identical spins but with opposite parity ($^+$5/2–$^-$5/2) in the deformed nuclei with more than order larger quadrupole moments ^{237}Np ($E = 60$ keV, $P_C \approx$ -1.2$\cdot 10^{-3}$, an estimation V_{NN} ~0.1 eV [5]) and ^{161}Dy ($E = 26$ keV, $P_C \approx$ -3.8$\cdot 10^{-3}$, and V_{NN} ~0.6 eV [6]). As one can see, the value of the P-odd effect for the deformed nuclei is also more than order larger in comparison with the case of the spherical nuclei. Moreover, reducing the transition energy about two times leads to increasing the value of the P-odd effect to about three times. Because of the gamma-transition energy (8.4 keV) in the deformed ^{169}Tm nucleus is about three times less than that of ^{161}Dy, one can expect the P_C value of the former at the level of 10^{-3}. Taking into account that at room temperature the Mössbauer effect probability for thulium is about twice larger than that for tin one can believe to estimate the ratio $< V^{P,T} > / < V^P >$for the former with accuracy better than 10^{-2}.

Note that all the above mentioned experimental P_C values are few orders larger than last theoretical estimations $\sim 10^{-7}$ in the contact approximation for weak NN-interaction in the framework of an oscillator shell model [12]. The authors [12] consider this disagreement as an indication of unknown mechanism of strengthening of parity violation and underline the importance of new measurements of the P-odd effects. Therefore, both new theoretical considerations and experimental measurements are needed to solve this discrepancy.

5 Conclusion

New measurements of P, T-violations applying the Mössbauer gamma-optical technique could substantially improve the existing experimental limitations at least by an order of magnitude and attain an accuracy comparable to neutron electric dipole moments measurements. Assuming the *CPT* theorem fulfilled, all such measurements could be a supplement to the results on searching for *CP*-violations in the EDM for evaluating the contribution from a weak neutral current. Proposed measurements of the P-odd and P, T-odd effects on the thulium nucleus also could serve this purpose.

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