THE QUANTUM-MECHANICAL NATURE OF TRI- AND ROT-ASYMMETRIES IN THE REACTIONS OF THE TERNARY FISSION OF NONORIENTED NUCLEI-TARGETS BY THE COLD POLARIZED NEUTRONS

S.G. Kadmensky

Voronezh State University

1.INTRODUCTION

In [P. Jessinger *et al.*,, Nucl. At. Phys. **65**, P. 662 (2002); F. Gonnenwein *et al.* Phys. Lett. B **652**, P. 13 (2007); A. M. Gagarski *et al.*, *Proceedings of the ISINN-16, Dubna, Russia*, *2008*, P. 356. (JINR, Dubna, 2009)] the differential cross sections $\frac{d\sigma_{n,f}}{d\Omega_3}$ for the reactions of the ternary fission of compound nuclei formed by the capture of cold longitudinally polarized neutrons by target-nuclei $^{233}\mathrm{U}$, $^{235}\mathrm{U}$ and $^{239}\mathrm{Pu}$ with the flight of α-particles as third particles the T-odd P-even asymmetries were experimentally investigated. The cross sections $\frac{d\sigma_{n,f}}{d\Omega_3}$ were analyzed in laboratory coordinate system (LCS), in which the axes Z and Y were chosen along the directions of the asymptotic wave vector $\vec{k}_{\mathrm{LF}}$ of the light fission fragment and the polarization vector of the incident neutron $\mathbf{s}_{\mathrm{n}}$ correspondently. The coefficients of the investigated T-odd asymmetries $D(\Omega_3)$ were calculated by the formula

$$D(\Omega_3)=\left(\frac{d\sigma_{n,f}^{(+)}}{d\Omega_3}-\frac{d\sigma_{n,f}^{(-)}}{d\Omega_3}\right)\Bigg/\left(\frac{d\sigma_{n,f}^{(+)}}{d\Omega_3}+\frac{d\sigma_{n,f}^{(-)}}{d\Omega_3}\right), \qquad (1)$$

where the signs (+/–) correspond to the two opposite directions of the neutron polarization vector $\vec{s}_n$.

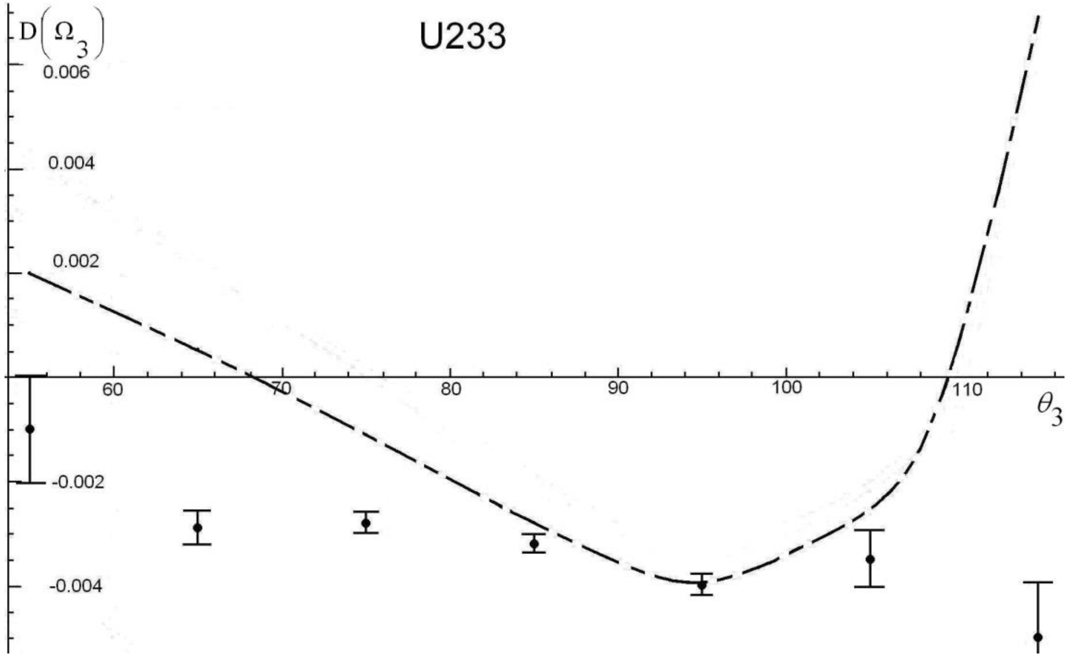


Figure 1.

As can be seen on Fig. 1, taken from [P. Jessinger *et al.*, Nucl. Instrum. Methods A **440**, P. 618 (2000)] for the target-nucleus ^{233}U, the coefficient $D(\Omega_3)$ does not change sign and is approximately constant in the wide range of angles θ_3. This asymmetry was called in [P. Jessinger *et al.*, Nucl. Instrum. Methods A **440**, P. 618 (2000)] as T-odd TRI (Time Reversal Invariance)-asymmetry, because authors of [P. Jessinger *et al.*, Nucl. Instrum. Methods A **440**, P. 618 (2000)] mistakenly assumed that it was due to a violation of T-invariance in nuclear reactions.

The mechanism of the investigated TRI-asymmetry appearance in question at the beginning [A. Gagarski *et. al.*, *Proceeding of 4-Internal Workshop*, P. 323 (Cadarache, France, 2012)] was related with the influence on the formation of the emitted third particle kinematic characteristics by classical catapult forces caused by decrease in the time of the collective rotation frequency for the fissile system after the scission of the fissile nucleus, and later [G. V. Danilyan *et al.*, *Proceedings of the ISINN-16, Dubna, Russia, 2008*, P. 350 (JINR, Dubna, 2009)] – with the influence on the indicated characteristics of the transverse bending-vibrations of the fissile nucleus in the vicinity of its scission point.

Figure 2.

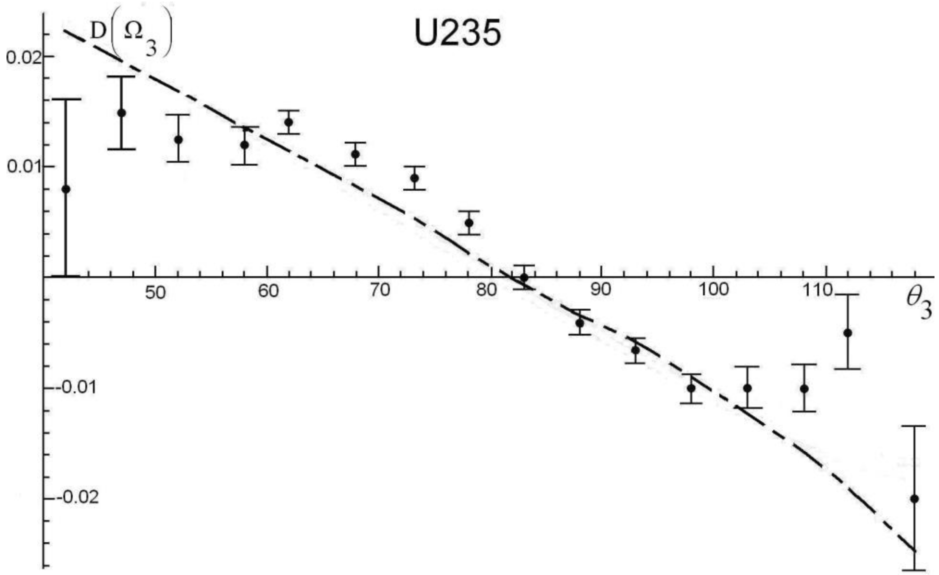
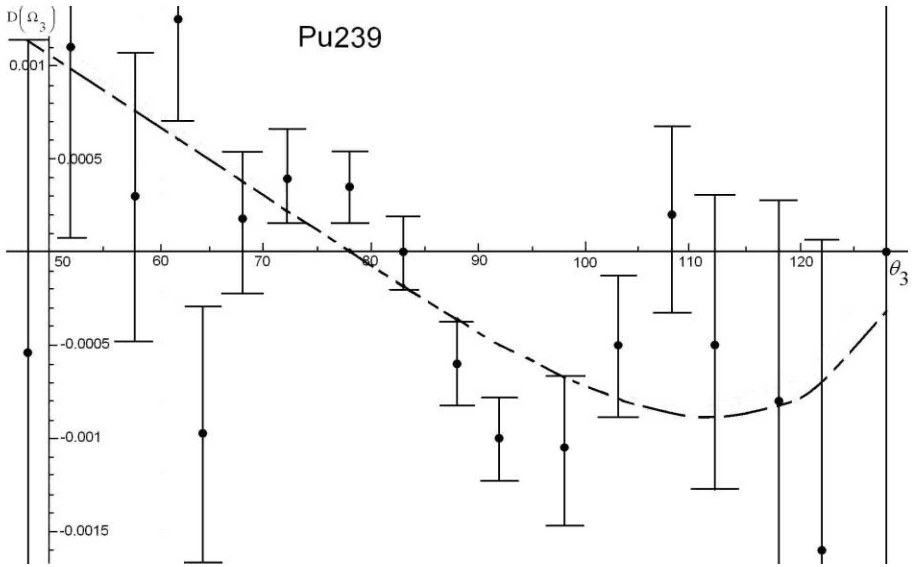


Figure 3.



As seen from Figs. 2 and 3, the experimental coefficients $D(\Omega_3)$ for target nuclei ^{235}U [P. Jessinger *et al.*,, Nucl. At. Phys. **65**, P. 662 (2002); F. Gonnenwein *et al.* Phys. Lett. B **652**, P. 13 (2007)] and ^{239}Pu [A. M. Gagarski *et al., Proceedings of the ISINN-16, Dubna, Russia, 2008,* P. 356. (JINR, Dubna, 2009)] change sign in the vinicity of the angle $\theta_3 \approx 82^\circ$ corresponding to the maximum angular distribution of prescission α-particles emitted during fission of the same nuclei by cold nonpolarized neutrons [6]. Such an asymmetry was related in papers [A. M. Gagarski *et al., Proceedings of the ISINN-14, Dubna, Russia,* 2006, P. 93 (JINR, Dubna, 2007); F. Gonnenwein *et al.* Phys. Lett. B **652**, P. 13 (2007); A. M. Gagarski *et al., Proceedings of the ISINN-16, Dubna, Russia, 2008,* P. 356. (JINR, Dubna, 2009)] with the appearance of the T-odd ROT (Rotation)-asymmetry, the name of which was related with the fact that it was described by the influence of the collective rotation of the polarized composite fissile nucleus on the angular distributions of the emitted α-particles taking into account in the classical scheme of trajectory calculations [A. M. Gagarski *et al., Proceedings of the ISINN-14, Dubna, Russia,* 2006, P. 93 (JINR, Dubna, 2007)].

In the general case, the T-odd asymmetry coefficients for the reactions of the ternary nuclear fission by cold polarized neutrons [P. Jessinger *et al.*,, Nucl. At. Phys. **65**, P. 662 (2002); F. Gonnenwein *et al.* Phys. Lett. B **652**, P. 13 (2007); A. M. Gagarski *et al., Proceedings of the ISINN-16, Dubna, Russia, 2008,* P. 356. (JINR, Dubna, 2009)] are presented in [S.G. Kadmensky, Phys. At. Nucl. **65**, P. 1390 (2002); **66**, P. 1846 (2003); **68**, P. 1968 (2005)], by the formula:

$$D(\Omega_3) = D_{ROT}(\Omega_3) + D_{TRI}, \quad (2)$$

where the coefficients $D_{ROT}(\Omega_3)$ and D_{TRI} – correspond to the T-odd ROT- and TRI-asymmetries and are constructed taking into account the mechanisms of their appearance considered above, as

$$D_{ROT}(\Omega_3) = 2\Delta \frac{A'(\Omega_3)}{2A(\Omega_3)},\ D_{TRI} = const, \qquad (3)$$

where Δ is the difference between the angle of rotation of the light fragment and the third particle, taking into account the rotation of the compound fissile nucleus, $A(\Omega_3)$ is the angular distribution of the third particle of the ternary nuclear fission by nonpolarized cold neutrons.

More recently in [G. V. Danilyan *et al.*, *Proceedings of the ISINN-16, Dubna, Russia, 2008*, P. 350 (JINR, Dubna, 2009). S.G. Kadmensky, Phys. At. Nucl. **65**, P. 1390 (2002); **66**, P. 1846 (2003); **68**, P. 1968 (2005), S. G. Kadmensky, L. V. Titova, Phys. At. Nucl. **72**, P. 1738 (2009)], in the differential cross sections $\frac{d\sigma_{n,f}}{d\Omega_3}$ of the delayed ternary fission target nucleus ^{233}U by cold polarized neutrons with as third particles evaporated by fission fragments of neutron and γ-quanta, the T-odd asymmetries were also found, the coefficients $D(\Omega_3)$ of which corresponded to the discussed above ROT-asymmetry (see Fig. 4 of [S. G. Kadmensky, L. V. Titova, Phys. At. Nucl. **72**, P. 1738 (2009)] for evaporative γ-quanta).

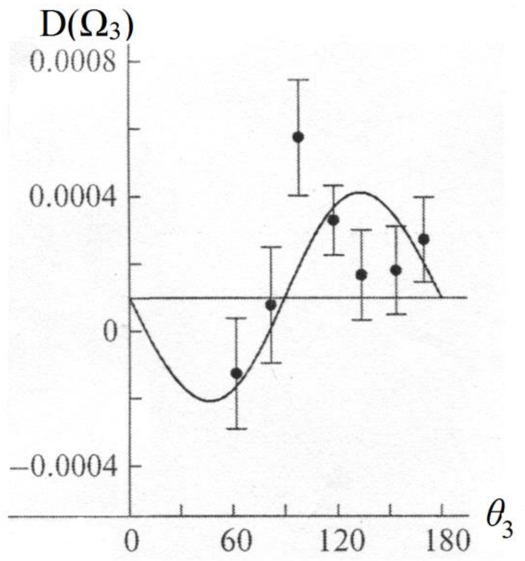


Figure 4.

At present time, active searches for mechanisms leading to the appearance of observable T-odd asymmetries are being conducted. The problem consists in finding of the answer to the question why the target nuclei ^{233}U, ^{235}U and ^{239}Pu close in charge, mass and having similar mass, charge, angular and energy distributions of products from binary and ternary fission by cold nonpolarized neutrons can have so much different form (Fig. 1-3) the coefficients of the discussed T-odd asymmetries in the true triple fission of these nuclei by cold polarized neutrons.

The aim of this paper is to demonstrate that all the discussed T-odd asymmetries for the third particles emitted in the reactions of true and delayed ternary fission of nonoriented target nuclei by cold polarized neutrons can in principle be explained within the framework of quantum fission theory [V. E. Bunakov, S. G. Kadmensky, Phys. At. Nucl. **66**, P. 1846 (2003)] taking into account the interference of the amplitudes of the binary and ternary fission of the neutron resonance states of the compound fissile nucleus.

2. CHARACTERISTICS OF THE LOW-ENERGY BINARY AND TERNARY NUCLEAR FISSION.

For the description of the binary and ternary low-energy fission it can be used the following facts:

1. the conservation of the direction of the symmetry axis of the fissile nucleus at all stages of its internal collective deformation motion [M. Brack, *et al*., Rev. Mod. Phys. **44**, 320 (1972)] to scission point of this nucleus to the fission fragments;
2. the coldness [Bohr, and B. Mottelson, *Nuclear Structure* (NY, Amsterdam, 1969, 1975) V. 1, 2] of fissile nucleus at all fission stages after passage of the second fission barrier to it's scission point;
3. connected with named above coldness the conservation of the projection K of the spin J of fissile nucleus on the symmetry axis [Bohr, and B. Mottelson, *Nuclear Structure* (NY, Amsterdam, 1969, 1975) V. 1, 2; S.G. Kadmensky, Phys. At. Nucl. **65**, P. 1390 (2002); S.G. Kadmensky, L.V. Rodionova, Phys. At. Nucl. **66**, 1219 (2003); S.G. Kadmensky, L.V. Rodionova, Bull. Russ. Sci. Phys. **69**, 751 (2004); S.G. Kadmensky, Phys. At. Nucl. **68**, P. 2030 (2005); S. G. Kadmensky, L. V. Titova, Phys. At. Nucl., **72**, P. 1738 (2009)];

4. connected with named above coldness the necessary of taking into account [S. G. Kadmensky, D. E. Lyubashevsky, L. V. Titova, Bull. Russ. Acad. Sci.: Phys., **79**, P. 975 (2015); S. G. Kadmensky, D. E. Lyubashevsky, V.E. Bunakov, Phys. At. Nucl., **77**, P. 198 (2015)] only zero wriggling- and zero bending-vibrations for the formation of angular and spin distributions of the fission fragments;
5. the nonevoporational and nonadiabatical mechanism of the flight of prescission third particles;
6. for P-even T-odd asymmetries in angular distributions of prescission ternary particles for the ternary fission of nonorineted target-nuclei by cold polarized neutrons the spin density matrix of the compound fissile nucleus must be constructed in the form, taking into account the interferential effects between different *s*-neutron resonances of the fissile compound nucleus with different spins J , *J'* with different projection *M*, *M'* :

$$\rho^{JJ'}_{MM'} = \frac{1}{2(2I+1)}\delta_{J,J'}\delta_{M,M'} + \frac{is_n}{2(2I+1)}A(J,J')\left[C^{J'M'}_{J1M1} + C^{J'M'}_{J1M-1}\right], \tag{4}$$

where $A(J,J')$ is defined as

$$A(J,J') = \delta_{J,J'}\left(\sqrt{\frac{J}{2(J+1)}}\delta_{J,J_<} - \sqrt{\frac{J+1}{2J}}\delta_{J,J_>}\right) - \sqrt{\frac{2J+1}{2J}}\delta_{J,J'+1} + \sqrt{\frac{2J+1}{2(J+1)}}\delta_{J,J'-1}. \tag{5}$$

The angular distribution of α-particle in ICS can be represented as

$$A(\theta) = \sum_l d_l Y_{l0}(\theta) = \sum_l \{d_l\} e^{i\delta_l} Y_{l0}(\theta) \tag{6}$$

where θ is angle between the direction of α-particle flight and the fissile nucleus symmetry axis, $\{d_l\}$ and δ_l is the real main value of d_l and it's phase. The α-particle motion has quasi-classical character since the Coulomb parameter $\eta = \frac{2Ze^2}{\hbar v_\alpha} \gg l$. In this case the phase δ_l has the form $\delta_l = \delta_{coul}$ and is independent from the α-particle orbital momentum l. Then the amplitude $A(\theta)$ can be represented as

$$A(\theta) = e^{i\delta^{кул}} \{A(\theta)\} = e^{i\delta^{кул}} \sum_l \{d_l\} Y_{l0}(\theta), \tag{7}$$

and the α-particle angular distribution $P(\theta)$ is defined as

$$P(\theta) = |A(\theta)|^2 = \{A(\theta)\}^2 \tag{8}$$

At the inversion of the α-particle wave vector $\mathbf{k}_3$ the distribution $P(\theta)$ transits to distribution $P(\pi - \theta)$:

$$P(\pi - \theta) = |A(\pi - \theta)|^2 = \{A(\pi - \theta)\}^2 . \tag{9}$$

Then presenting the amplitude $A(\theta)$ (6) as

$$A(\theta) = A^{ev}(\theta) + A^{odd}(\theta) \qquad (10)$$

where the amplitude $A^{ev}(\theta)$ ($A^{odd}(\theta)$) is defined by the formula (6) with only even (odd) orbital moments, from formulae (8, 9) it can be presented:

$$\left\{A^{ev}(\theta)\right\} = \frac{1}{2}\left[\sqrt{P(\theta)} + \sqrt{P(\pi-\theta)}\right]; \left\{A^{odd}(\theta)\right\} = \frac{1}{2}\left[\sqrt{P(\theta)} - \sqrt{P(\pi-\theta)}\right]; \left\{A(\theta)\right\} = \sqrt{P(\theta)} \qquad (11)$$

Using the normalized experimental α-particle angular distribution $P(\theta)$ [M. Mutterer, J.P. Theobald, *Nuclear Decay Modes* (Bristol: Inst Publ., 1996)] for ternary fission of target-nuclei ^{235}U by cold nonpolarized neutrons:

$$P(\theta) = A\exp\left(-\frac{1}{2}\left(\frac{\theta-\theta_0}{w}\right)^2\right), \qquad (12)$$

where θ_0= 81.65°, w = 11.57° , the amplitudes $\left\{A^{ev}(\theta)\right\}$ and $\left\{A^{odd}(\theta)\right\}$ were calculated. These amplitudes are presented on the Fig. 5, where lines 1,2 and 3 correspond to $\left\{A(\theta)\right\}$, $\left\{A^{ev}(\theta)\right\}$ and $\left\{A^{odd}(\theta)\right\}$.

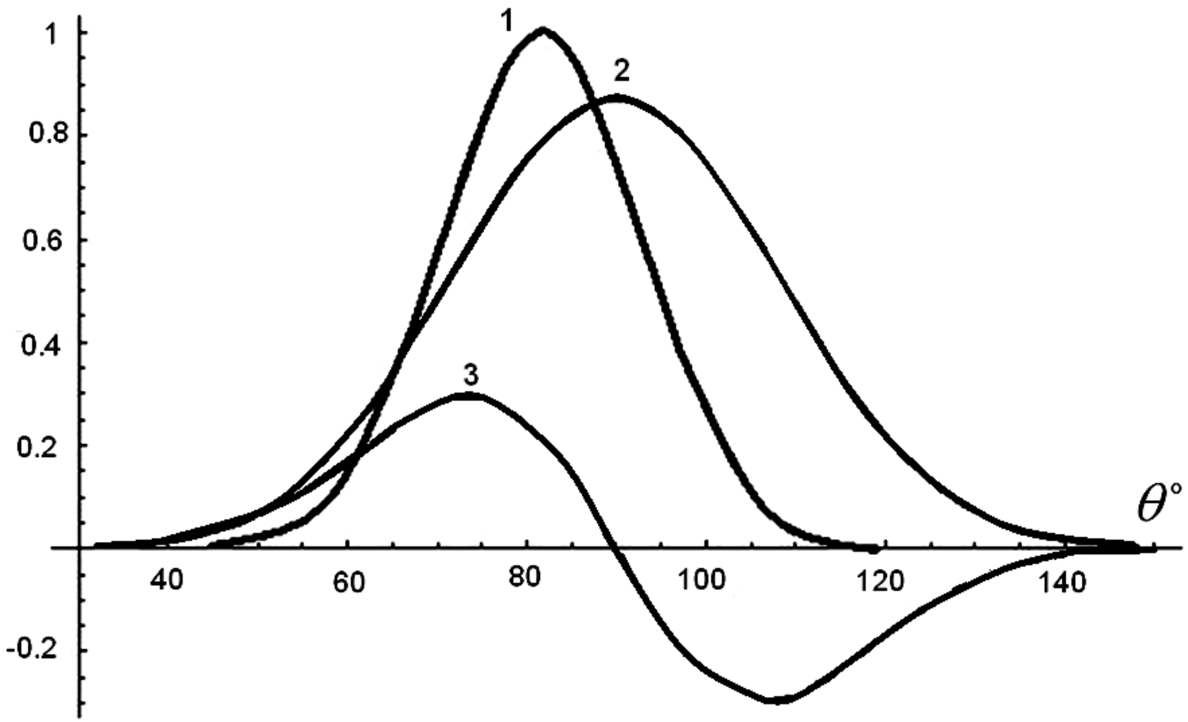


Figure 5.

From Fig. 5 it can be seen that the maximal value of amplitude $\{A^{ev}(\theta)\}$ with positive sign exceeds the maximal value of amplitude $\{A^{odd}(\theta)\}$ by factor 3.

3. T-ODD TRI- AND ROT-ASYMMETRIES FOR TERNARY FISSION AND CORIOLIS INTERACTION.

The nature of all types of T-odd asymmetries in the reactions of true ternary fission of nonoriented nuclei-targets by cold polarized neutrons with emission of light third particles was explained in [V. E. Bunakov, S. G. Kadmensky, Phys. At. Nucl. **66**, P. 1846 (2003); V. E.Bunakov, S. G. Kadmensky, S. S. Kadmensky, Phys. At. Nucl., **71**, P. 1887 (2008); D. E. Lyubashevsky, S. G. Kadmensky Bull. Russ. Acad. Sci.: Phys., V. 74, P. 791 (2010); S. G. Kadmensky, D. E. Lyubashevsky, L. V. Titova, Bull. Russ. Acad. Sci.: Phys., **75**, P. 989 (2011)] by the influence of the rotation compound fissile nucleus on the angular distributions of ternary fission products through the Hamiltonian H_{cor} of the Coriolis interaction consisting of two terms, the first term associated with the interaction of the total spin J fissile nucleus with the orbital angular momentum L fission fragments and the second term associated with the interaction of the total spin J of the fissile nucleus with the orbital angular momentum l of the third particle:

$$H_{cor} = -\frac{\hbar^2}{2\Im_{\perp}}\left(\left[J_+L_- + J_-L_+\right] + \left[J_+l_- + J_-l_+\right]\right), \tag{13}$$

where the operators $J_{\pm}$, $L_{\pm}$ and $l_{\pm}$ are defined in ICS of the fissile nucleus as

$$J_{\pm} = J_1 \pm iJ_2;\; L_{\pm} = L_1 \pm iL_2,\; l_{\pm} = l_1 \pm il_2 \tag{14}$$

and $\Im_{\perp}$ is the moment of inertia of the fissile nucleus for its rotation axis perpendicular to the symmetry axis of the nucleus.

The action of the operators $J_{\pm}$ and $L_{\pm}$ on the function $D^{J}_{MK}(\omega)$ and $Y_{LK_L}(\Omega'_{LF})$, $Y_{LK_l}(\Omega_{\alpha})$, is defined as:

$$\begin{gathered} \mathrm{J}_{\pm} D^{J_s}_{M_s K_s}(\omega) = \left[\left(J_s \pm K_s\right)\left(J_s \mp K_s + 1\right)\right]^{1/2} D^{J_s}_{M_s (K_s \mp 1)}(\omega); \\ L_{\pm} Y_{LK_L}(\Omega'_{LF}) = \left[\left(L \mp K_L\right)\left(L \pm K_L + 1\right)\right]^{1/2} Y_{L(K_L \pm 1)}(\Omega'_{LF}). \\ l_{\pm} Y_{LK_l}(\Omega_{\alpha}) = \left[\left(l \mp K_l\right)\left(l \pm K_l + 1\right)\right]^{1/2} Y_{l(K_l \pm 1)}(\Omega_{\alpha}) \end{gathered} \tag{15}$$

Since the Coriolis interaction is weak, it can be taken into account in the first order of perturbation theory.

$$Y_{L0}\left(\theta_{LF_0, k_\alpha}\right) = \sqrt{\frac{4\pi}{2L+1}} \sum_{K_L} Y_{LK_L}\left(\theta_{LF_0}\right) Y^{*}_{LK_L}\left(\Omega_{k_\alpha}\right) \tag{16}$$

Using the adiabatic approximation associated with the slow rotation of the motion of the fissile system in comparison with its internal motion, and neglecting the interaction of these types of motion with each other, the wave function of the fissile system $\Psi^{J_s M_s}_{K_s}$ in the outer (cluster) region where unbound ternary fission products are already formed has form:

$$\psi_{K_s}^{J_s M_s} = \sum_c \sqrt{\frac{2J_s+1}{16\pi^2}} \sqrt{\frac{\Gamma_{cK}}{\hbar \upsilon_c}} \frac{e^{ik_c \rho}}{\rho^{5/2}} \left\{ D_{M_s K_s}^{J_s}(\omega) \chi_{K_s} + (-1)^{J_s+K_s} D_{M_s -K_s}^{J_s}(\omega) \chi_{\overline{K_s}} \right\} \times$$

$$\times B^{(0)}(\Omega'_{LF}) A^{(0)}(\Omega'_3), \qquad (17)$$

where Ω'_{LF}, Ω'_3 is the angle between the direction of emission of the light fragment and the axis of symmetry of the nucleus, between the direction of flight the third particle and the direction of flight of the light fragment.

Because of the influence of the pumping effect of the large values of the relative orbital fission moments associated with zero wriggling-vibrations of the fissile nucleus, the amplitude of the angular fission fragments distribution normalized per unit is in formula (17) coincides with a high degree of accuracy with the amplitude of the "smeared" δ-function:

$$B^{(0)}(\Omega'_{LF}) = \frac{1}{\sqrt{2\pi}} \delta^{1/2}(\cos\theta'_{LF} - 1) = \sum_{L=0}^{L_m} b_l Y_{L0}(\Omega'_{LF}), \qquad (19)$$

where

$$b_{l=} \left\{ \sum_{L=0}^{L_m} (2L+1) \right\}^{-1/2} \sqrt{2L+1}$$

Let us consider the effect of the compound polarized fissile nucleus rotation on the fission fragments angular distributions by means of the first term of the Hamiltonian of the Coriolis interaction H_{cor}.

The action of this term in the Hamiltonian of the Coriolis interaction H_{cor} (13), which is related to the orbital angular momentum L by the amplitude $B^{(0)}\left(\Omega'_{LF}\right)$ in the first order of perturbation theory, has the form:

$$B^{(cor)}\left(\Omega'_{LF}\right)=b\left(L_m\right)\sum_L\sqrt{L\left(L+1\right)}\left[Y_{L(-1)}\left(\Omega'_{LF}\right)-Y_{L1}\left(\Omega'_{LF}\right)\right]\sqrt{\left(2L+1\right)/4\pi}= \\ =-2\cos\varphi'_{LF}\frac{d\delta^{1/2}\left(\cos\theta'_{LF}-1\right)}{d\theta'_{LF}}. \quad (20)$$

Carrying out the similar transformations for the amplitude of the third particle angular distribution third particle $A^{(0)}\left(\Omega'_3\right)$ (6), we obtain:

$$A^{cor}\left(\Omega_{LF_0,k_\alpha}\right)=\sum_{l\geq1}b_l\sqrt{l\left(l+1\right)}\left[Y_{l(-1)}\left(\Omega_{LF_0,k_\alpha}\right)-Y_{l1}\left(\Omega_{LF_0,k_\alpha}\right)\right]=-2\cos\varphi'_3\sum_{l\geq1}b_l\frac{dY_{l0}\left(\theta_{LF_0,k_\alpha}\right)}{d\theta_{LF_0,k_\alpha}}. \quad (21)$$

Then the asymmetry coefficient (1) takes the form:

$$D\left(\theta,\varphi\right)=D_{ROT}\left(\theta,\varphi\right)+D_{TRI}\left(\theta,\varphi\right) \quad (22)$$

where

$$D_{ROT}\left(\theta,\varphi\right)=\alpha_{ROT}\frac{d\left\{A^{(0)ev}\left(\theta\right)\right\}}{d\theta}\frac{1}{\left\{A^{(0)}\right\}}, \qquad (23)$$

$$D_{TRI}\left(\theta,\varphi\right)=\alpha_{TRI}\frac{d\left\{A^{(0)\,\mathrm{odd}}\left(\theta\right)\right\}}{d\theta}\frac{1}{\left\{A^{(0)}\right\}}, \qquad (24)$$

and

$$\alpha_{ROT}=\left(\cos(\delta_{sJ_s s' J_{s'}}+\bar{\delta}_{ev}-\delta^0)k^{ev}-\cos(\delta_{sJ_s s' J_{s'}})\right)\Delta\theta, \qquad (25)$$

$$\alpha_{TRI}=\left(\cos(\delta_{sJ_s s' J_{s'}}+\bar{\delta}_{odd}-\delta^0)k^{odd}-\cos(\delta_{sJ_s s' J_{s'}})\right)\Delta\theta, \qquad (26)$$

and the angle of rotation $\Delta\theta\left(K_s,J_s,J_{s'}\right)$ represented as

$$\Delta\theta\left(K_s,J_s,J_{s'}\right)=-\omega\left(K_s,J_s,J_{s'}\right)\tau, \qquad (27)$$

The effective angular velocity of rotation $\omega\left(K_s,J_s,J_{s'}\right)$ is determined by the relation:

$$\omega\left(K_s,J_s,J_{s'}\right)=\frac{\hbar p_n}{2\bar{\mathfrak{I}}_0}g\left(K_s,J_s,J_{s'}\right), \qquad (28)$$

where

$$g\left(K_s, J_s, J_{s'}\right)=\begin{cases}\dfrac{J_s\left(J_s+1\right)-K_s^2}{J_s} & \text{для } J_s=I+1/2\equiv J_>\\[2ex] -\dfrac{J_s\left(J_s+1\right)-K_s^2}{J_s+1} & \text{для } J_s=I-1/2\equiv J_<\end{cases}$$

$$g\left(K_s, J_<, J_>\right)=g\left(K_s, J_>, J_<\right)=\frac{K_s\sqrt{J_s^2-K_s^2}}{J_>} \tag{29}$$

Transform the formulas (23) and (24) with allowance for formulas (25) and (26), we obtain:

$$D_{ROT}\left(\theta,\varphi\right)=\alpha_{ROT}\frac{d\left\{A^{(0)ev}\left(\theta\right)\right\}}{d\theta}\frac{\cos\varphi}{\left\{A^{(0)}\right\}}\Delta\theta, \tag{30}$$

$$D_{TRI}\left(\theta,\varphi\right)=\alpha_{TRI}\frac{d\left\{A^{(0)\,\mathrm{odd}}\left(\theta\right)\right\}}{d\theta}\frac{\cos\varphi}{\left\{A^{(0)}\right\}}\Delta\theta, \tag{31}$$

Along with the χ^2 method, this formula was used in [D. E. Lyubashevsky, S. G. Kadmensky Bull. Russ. Acad. Sci.: Phys., V. 74, P. 791 (2010)] to analyze angular dependences of the $D^{\exp}\left(\Omega_\alpha\right)$ coefficients for reactions of the true ternary fission of ^{233}U, ^{235}U, and ^{239}Pu target nuclei by cold polarized neutrons [P. Jessinger *et al*.,, Nucl. At. Phys. **65**, P. 662 (2002); F. Gonnenwein *et al*. Phys. Lett. B **652**, P. 13 (2007); A. M. Gagarski *et al., Proceedings of the ISINN-16, Dubna, Russia, 2008,* P. 356. (JINR, Dubna, 2009)],and to calculate the values of D_{ROT} and D_{TRI} in (22). It can be seen from Figs. 2 and 3 that the angular dependences of coefficients $D^{\exp}\left(\Omega_\alpha\right)$ and $D\left(\Omega_\alpha\right)$ on angle θ_3 that were calculated in this manner are in good agreement with one another for the ^{235}U and ^{239}Pu target nuclei with close values of constants D_{ROT} = 0.152, D_{TRI} = 0.189 and D_{ROT} = 0.010, D_{TRI} = 0.017, respectively.

At the same time, the angular dependence of the $D\left(\Omega_\alpha\right)$ coefficient for the ^{233}U target nucleus in Fig. 1, calculated in [D. E. Lyubashevsky, S. G. Kadmensky Bull. Russ. Acad. Sci.: Phys., V. 74, P. 791 (2010)] using the χ^2 method and constants D_{ROT} = -0.027 and D_{TRI} = 0.078, for which the contribution from coefficient D_{ROT} can be ignored in practice, is in accord with the similar dependence of experimental coefficient $D^{\exp}\left(\Omega_\alpha\right)$ in the 60° < θ_3 < 110° range of angles, where the principal value of undisturbed experimental amplitude $A^0\left(\theta_3\right)$ differs significantly from zero. At the same time, a notable discrepancy is observed in the behavior of the theoretical $D\left(\Omega_\alpha\right)$ and experimental $D^{\exp}\left(\Omega_\alpha\right)$ coefficients in the θ_3 < 60° and θ_3 > 110° ranges of angles. It cannot be ruled out that this discrepancy is associated, on the one hand, with the inaccuracy of the above definition [D. E. Lyubashevsky, S. G. Kadmensky Bull. Russ. Acad. Sci.: Phys., V. 74, P. 791

(2010); S. G. Kadmensky, D. E. Lyubashevsky, L. V. Titova, Bull. Russ. Acad. Sci.: Phys., **75**, P. 989 (2011)] of the amplitudes $\left\{A_{ev}^{cor}\left(\theta_3\right)\right\}$ and $\left\{A_{odd}^{cor}\left(\theta_3\right)\right\}$ via amplitudes $\frac{d\left\{A_{ev}^{0}\left(\theta_3\right)\right\}}{d\theta_3}$ and $\frac{d\left\{A_{odd}^{0}\left(\theta_3\right)\right\}}{d\theta_3}$ the other hand, with the failure to establish genuine coincidences of the third particle with the light fission fragment in the above range of angles.

4. CONCLUSION

In the present study of T-odd asymmetries for prescission and evaporative third particles appearing in the ternary fission of the actinide nuclei by cold polarized neutrons it has made possible to concretize the basic dynamic effects for the binary and ternary fission of nuclei, which are defined at formation of these asymmetries. It is shown that the considered T-odd asymmetries can be classified by taking into account the effects associated with interference of the fission amplitudes of neutron resonances and influences differently in the case of the appearance of even and odd orbital moments of the third particles.