P-even T-odd asymmetries in differential cross sections of fission reactions of nonorientied nuclei by cold polarized neutrons with emission of prescission and evaporation light particles

S.G. Kadmensky, D.E. Lyubashevsky

Voronezh State University, 394006, Russia, Voronezh, University square, 1

In the quantum theory of fission [1] P-even T-odd asymmetries in differential cross sections $d\sigma_{nf,\alpha}/d\Omega$ for fission reactions of nonoriented nuclei by cold polarized neutrons with the emission of prescission α-particles can be connected with triple $A_{\alpha,3}(\theta)=\left(d\sigma^1_{nf,\alpha}(\theta)/d\Omega\right)_3 = B_{\alpha,3}\left(\cos^2\theta\right)\left(\boldsymbol{\sigma}_n[\mathbf{k}_{LF},\mathbf{k}_\alpha]\right)$ and quinary $A_{\alpha,5}(\theta)=\left(d\sigma^1_{nf,\alpha}(\theta)/d\Omega\right)_5 = B_{\alpha,5}\left(\cos^2\theta\right)\left(\boldsymbol{\sigma}_n[\mathbf{k}_{LF},\mathbf{k}_\alpha]\right)(\mathbf{k}_{LF},\mathbf{k}_\alpha)$ scalar correlators that appear in the component $d\sigma^1_{nf,\alpha}(\theta)/d\Omega$ of cross section $d\sigma_{nf,\alpha}/d\Omega$ linearly related to the neutron polarization vector $\boldsymbol{\sigma}_n$. These correlators can be built taking into account the influence of Coriolis interaction of the total spin of fissile compound nuclei with orbital momenta of emitted particles: $A_{\alpha,3,5}(\theta)=\Delta_{\alpha,3,5}\,d\left(d\sigma^0_{nf,\alpha}/d\Omega\right)_{3,5}/d\theta$ (1), where $\left(d\sigma^0_{nf,\alpha}/d\Omega\right)_{3,5}$ are odd and even components of cross section $\left(d\sigma^0_{nf,\alpha}/d\Omega\right)$ of fission reaction with nonpolarized neutrons and $\Delta_{\alpha,3,5}$ are angles of the rotation of α- particle wave vector $\mathbf{k}_\alpha$ relatively to analogous vector $\mathbf{k}_{LF}$ of light fragment. Taking into account that correlators $A_{\alpha,3}(\theta)$ and $A_{\alpha,5}(\theta)$ are proportional to $\sin\theta$ and $\cos\theta\sin\theta$ correspondly and have symmetries $A_{\alpha,3,5}(\theta)=\pm A_{\alpha,3,5}(\pi-\theta)$, they can be presented as $A_{\alpha,3,5}(\theta)= 1/2\left[d\sigma^1_{nf,\alpha}(\theta)/d\Omega \pm d\sigma^1_{nf,\alpha}(\pi-\theta)/d\Omega\right]$ (2). Using in (2) experimental values of cross section $d\sigma^1_{nf,\alpha}(\theta)/d\Omega$ the calculation of the experimental values $A^{\exp}_{\alpha,3,5}(\theta)$ were produced for target nuclei ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu. The comparison on the base of the χ^2-method of $A^{\exp}_{\alpha,3,5}(\theta)$ with theoretical values (1) makes it possible to find the values of the rotation angles $\Delta_{\alpha,3,5}$. The calculated values of $A_{\alpha,3,5}(\theta)$ (1) coincide with $A^{\exp}_{\alpha,3,5}(\theta)$ (2) for all nuclei ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu with the exception of $A_{\alpha,3}(\theta)$ for ^{233}U. This description can be associated with the influence of transverse vibrations of compound fissile nuclei in the vicinity of their scission points [2]. In the case of prescission α-particles the angles $\Delta_{\alpha,3}$ have positive values for ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu, but angles $\Delta_{\alpha,5}$ change signs from positive for ^{235}U, ^{239}Pu,^{241} Pu to negative for ^{233}U. The negative signs of $\Delta_{\alpha,5}$ in principle is not possible for the quasi-classical method of trajectory calculations [2], in contrast to the quantum approach [1], where due to the taking into account of interference effects the signs $\Delta_{\alpha,3,5}$ can have negative values. In the case of the evaporation neutrons and γ- quanta emission in cross section $d\sigma^1_{nf,n,\gamma}(\theta)/d\Omega$ only quinary scalar correlations $A_{5,n,\gamma}(\theta)$ can appear because of properties of $d\sigma^0_{nf,n,\gamma}(\theta)/d\Omega$. The signs of $\Delta_{n,5}$ and $\Delta_{\gamma,5}$ for evaporation neutrons and γ- quanta coincide with each other for ^{233}U and ^{235}U, but for passing from ^{235}U to ^{233}U they change signs from positive to negative. Signs of $\Delta_{n,5}$ and $\Delta_{\gamma,5}$ for evaporation neutrons and γ -quanta coincide with signs of $\Delta_{\alpha,5}$ for prescission α-particles for nuclei ^{233}U and ^{235}U. This coincidence is indicated by the unit quantum mechanical nature of P-even T-odd asymmetries for prescission α-particles and evaporation neutrons and γ-quanta.

1. S.G. Kadmensky, V.E. Bunakov, D.E. Lyubashevsky, Bull. Russ. Acad. Sci. Phys., V. **83**, P. 1236 (2019).
2. A. Gagarski, F. Goennenwein, I. Guseva *et al.*, Phys. Rev. C **93**, 054619 (2016).