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The Polarization Effects of the Process $\tau \to K^-\pi^0\nu_\tau$ in the Nambu–Jona-Lasinio Model

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In the present paper we consider the transverse polarization effects of the process $\tau \to K^-\pi^0\nu_\tau$ in the framework of the Nambu–Jona-Lasinio (NJL) model.

The most of the phenomenological models are based on the chiral symmetry of strong interractions and on the vector dominance methods [1–5]. The methods of calculation of angular distributions of the differential widths of the polarized τ-lepton are presented in [6].

The NJL model [7–10] is intended for description of the four meson nonets in the ground states. Its new version, the extended NJL model [10–13] allow one to describe mesons in the first radially-excited states. Unlike other phenomenological models, they include a minimal amount of model parameters and does not require insertion of arbitrary parameters for description of the specific processes.

Recently, several hadronic τ-decays were calculated in the framework of the NJL models, specifically $\tau \to \pi\omega\nu_\tau$ [14], $\tau \to (\eta,\eta')2\pi$ [15], $\tau \to (\pi,\pi(1300))\nu_\tau$ [16], $\tau \to K^-\pi^0\nu_\tau$ [17], $\tau \to (\eta,\eta')K^-\nu_\tau$ [18], $\tau \to K^0K^-\nu_\tau$ [19]. However, the polarization effects were not taken into account.

In the present work the process $\tau \to K^-\pi^0\nu_\tau$ is calculated in the framework of the NJL model with considering of the polarization of τ-lepton.

The excited vector meson $K^*(1410)$ gives insignificant contribution. Therefore, one can to use the standard NJL model. The amplitude for this process was obtained in [17]:

$$T = -\frac{i}{2}G_F V_{us} Z_K \frac{g_\pi}{g_K} l^\mu \times$$
$$\times \left\{ g_{\mu\nu} + \frac{g_{\mu\nu}\left[q^2 - \frac{3}{2}(m_s - m_u)^2\right] - q_\mu q_\nu}{M^2_{K^*} - q^2 - i\sqrt{q^2}\Gamma_{K^*}} \right\} \times$$
$$\times (p_K - p_\pi)^\nu, \qquad (1)$$

where $G_F = 1.16637 \cdot 10^{-11}\,\mathrm{MeV}^{-2}$ is the Fermi constant, $V_{us} = 0.2252$ is the element of the Cabibbo–Kobayashi–Maskawa matrix, $l^\mu = \bar{\nu}_\tau\gamma^\mu\tau$ is the vector part of the lepton current, $q = p_K + p_\pi$, $m_u = 280$ MeV and $m_s = 420$ MeV are the constituent quark masses [13, 20], $M_{K^*} = 896$ MeV and $\Gamma_{K^*} = 46$ MeV are the mass and the full width of the vector meson [21].

For the purpose of considering the polarization of τ-lepton, one has to use the relation:

$$u_\tau \bar{u}_\tau \to \frac{1}{2}\left[(p_\tau\gamma) + m_\tau\right]\left[1 - \gamma^5(a\gamma)\right], \qquad (2)$$

where a is the polarization vector. One can put $|\mathbf{a}| = 1$.

To estimate the influence of the accounting of polarization on the differential width we calculate the relation:

$$\frac{\dfrac{d\Gamma}{d^3p_\pi d^3p_K} - \dfrac{d\Gamma}{d^3p_\pi d^3p_K}}{\dfrac{d\Gamma}{d^3p_\pi d^3p_K} + \dfrac{d\Gamma}{d^3p_\pi d^3p_K}}. \qquad (3)$$

Similar effects in QCD were considered in [22].

The dependence of the relation (3) on the invariant mass of the final mesons and $\varepsilon = \frac{\varepsilon_\pi}{\varepsilon_K}$ for the case of transverse polarization providing the maximal asymmetry is shown in Fig. 1.

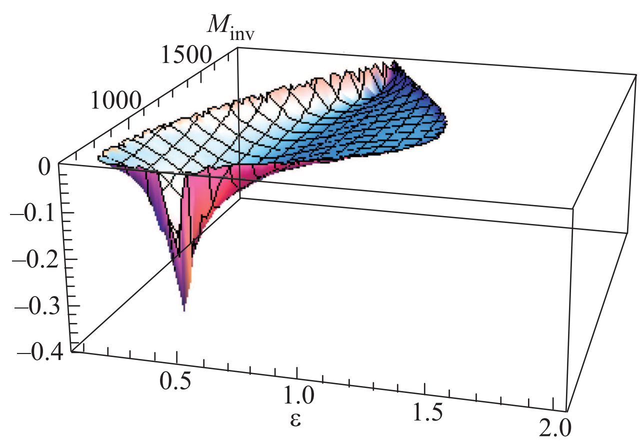

Fig. 1. (Color online) The asymmetry of the differential width due to transverse polarization of τ-lepton

The resulting asymmetry for transverse polarized lepton is of order 10 % and can be measured in high

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statistics experiments. It provides the new sensitive test for NJL model.

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