ON THE $\tau \to VP\nu_\tau$ DECAYS

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The $\tau \to VP\nu_\tau$ decays of τ-lepton are studied using the method of phenomenological chiral Lagrangians(PCL). The expressions of weak hadronic currents between pseudoscalar and vector meson states and strong interaction Lagrangian between axial-vector, vector and pseudoscalar mesons are obtained. Calculated partial widths for these decays are compared with the available theoretical and experimental data.

In this paper the $\tau \to VP\nu_\tau$ decays of τ-lepton are studied using the method of phenomenological chiral Lagrangians (PCL) [1]. Such decay channels are unique "laboratory" for verification of weak hadron currents between pseudoscalar and vector meson states. Main uncertainty in study of these decays is connected with this weak hadron current and so investigation of these decays are of interest. Note that the hadron decays of τ-lepton up to three pseudoscalar mesons in final state have been studied also in the framework of this method [2,3].

In the PCL, the weak- interaction Lagrangian has the form

$$L_W = \frac{G_F}{\sqrt{2}} J_\mu^h l_\mu^+ + h.c.,$$

where $G_F \simeq 10^{-5}/m_P^2$ is the Fermi constant,

$l_\mu = \bar{u}_l \gamma_\mu (1+\gamma_5) u_{\nu_l}$ is the lepton current, and hadron currents have the form [1]

$$J_\mu^h = J_\mu^{1+i2} \cos Q_c + J_\mu^{4-i5} \sin Q_c,$$

where Θ_c is the Cabibbo angle,

Weak hadron currents between pseudoscalar and vector meson states are obtained by including the gauge fields of these mesons in covariant derivatives [4]. The weak hadron currents we obtained in this way have the form

$$J^i_\mu = F_\pi g v^a_\mu \varphi^b f_{abi}, \tag{1}$$

where $F_\pi = 93$ MeV, g is the "universal" coupling constant, that is fixed from experimental $\rho \to \pi\pi$ decay width:

$$\frac{g^2}{4\pi} \simeq 3.2,$$

v^a_μ and φ^b represent the fields of the 1^- and 0^- - mesons, respectively.

Axial-vector and vector meson currents are defined as

$$J^i_\mu = \frac{m_v^2}{g} v^i_\mu + \frac{m_a^2}{g} a^i_\mu,$$

where m_v and m_a are the masses of vector and axial-vector mesons, respectively.

The strong interaction Lagrangian of axial-vector mesons with vector and pseudoscalar mesons is obtained also by this way and has the form

$$L_S(1^+, 1^-, 0^-) = -F_\pi g^2 f_{klm} a^k_\mu v^l_\mu \varphi^m. \tag{2}$$

The decay amplitudes for these channels can be written as [5]

$$M\left(\tau \to VP\nu_\tau\right) = G_F \epsilon^\lambda_\mu \bar{U}(k_v)\gamma_\mu[f_1 + g_1\gamma_5 + \hat{p}\left(f_2 + g_2\gamma_5\right) +$$

$$+\hat{p}_1\left(f_3 + g_3\gamma_5\right)]U(k_\tau),$$

where ϵ^λ_μ is the polarization vector of $1^\pm$- mesons, f_i and g_i are the form factors that depend on the final state momenta; $q = p - p_1$; k_l, k_v are the lepton 4-momenta ($\hat{p}_i \equiv p_{i\mu}\gamma^\mu$).

Using these Lagrangians we calculated the partial widths of $\tau \to VP\nu_\tau$ decays by means of the TWIST code TWIST [6]. The results are shown in the table 1. In columns I and II are listed, respectively, the results without and with the spin-1 meson contributions.

Table 1 shows that the calculated branching ratios of $\tau^- \to K^{*0}K^-\nu_\tau$ and $\tau^- \to \bar{K}^{*0}\pi^-\nu_\tau$ decays are in a good agreement with available experimental data [7]. Note that according to (1) the branching ratio of the $\tau^- \to \omega\pi^-\nu_\tau$ decay is equal to zero in the PCL method; as in [8], this channel can be realized via effects of secondary importance.

Thus, the obtained expressions (1) and (2) by including the gauge fields of axial-vector and vector mesons in covariant derivatives allow to describe $\tau \to VP\nu_\tau$ decays in satisfactory agreement with the available experimental data. We hope that the new level of precision of future measurements will allow us to evaluate the status of this method and clarify the problems related to weak interactions of hadrons.

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Table 1. The partial widths ($in 10^9 sec^{-1}$) for the $\tau \to VP\nu_\tau$ decays.

Decays	I	II	Experiment [7]
$\tau^- \to \rho^0 \pi^- \nu_\tau$	0.22×10^2	0.153×10^2	$---$
$\tau^- \to \rho^- \pi^0 \nu_\tau$	0.22×10^2	0.88×10^1	$---$
$\tau^- \to K^{*0} K^- \nu_\tau$	5.69	8.27	$6.9 \pm 1.7 \pm 1.4$
$\tau^- \to \bar{K}^{*0} \pi^- \nu_\tau$	0.48	2.5	$8.6 \pm 3.4 \pm 1.7$
$\tau^- \to K^{*-} \pi^0 \nu_\tau$	0.24	0.58	$---$
$\tau^- \to \rho^- \bar{K}^0 \nu_\tau$	0.23	0.34	$---$
$\tau^- \to \rho^0 K^- \nu_\tau$	0.12	0.17	$---$
$\tau^- \to \omega K^- \nu_\tau$	0.32	0.47	$---$