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ON t–QUARK DECAY

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ABSTRACT

An extended electroweak model with second rank antisymmetric tensor fields is proposed. The effective interactions resulting from the exchange of these fields have specific dependence on the transfer momentum. This leads to the introduction of new model-independent muon decay parameters (*Mod. Phys. Lett. A9 (1994) 2979*), which can be measured experimentally in SLAC and TRIUMF. The new tensor interactions can effect the three-particles semileptonic meson decays (*Mod. Phys. Lett. A8 (1993) 2753*). In this connection it will be interesting to proposed new experiments on $K^+ \to l^+\nu\gamma$, $K^+ \to \pi^o l^+\nu$ decays in DAΦNE. The K_L-K_S mass difference sets constraints on the tensor particles masses. The mass of the lightest tensor particle could be less than the t-quark mass. Therefore the lightest tensor particle may give an additional to the W-boson contribution into the t- quark decay with the same signature.

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The study of superheavy particle decays, like t-quark ones, offers the possibility of revealing a new physics. This new physics may be connected for example with new interactions of the known particles, as well as with the existence of new particles in Nature. These new particles may be of known types – scalar or vector ones. There also exists another possibility, which will be the topic of my letter, that the new particles belong to a new type of elementary particles – the antisymmetric tensor particles. The antisymmetric tensor corresponding to these particles, like the antisymmetric electromagnetic field strength $F_{\mu\nu}$, describes in a relativistic invariant way a three-vector and a three-pseudovector. Therefore the introduction of the antisymmetric tensor particles into the field theory allows a different possibility for describing the vector particles and their interaction [1].

The coupling of fermions with bosons is introduced by Yukawa terms. For P-conserving interactions these Yukawa terms are: $\bar{\Psi}\Psi \cdot S$, $\bar{\Psi}\gamma^5\Psi \cdot P$, $\bar{\Psi}\gamma^\mu\Psi \cdot V_\mu$, $\bar{\Psi}\gamma^5\gamma^\mu\Psi \cdot A_\mu$, $\bar{\Psi}\sigma^{\mu\nu}\Psi \cdot T_{\mu\nu}$ corresponding to the scalar, pseudoscalar, vector, pseudovector and tensor couplings. The first four terms are widely used and detailedly analyzed. Here we will discuss the last term, assuming that the boson tensor field is as fundamental as the scalar and vector ones. In case when the mass of the new tensor particle is less than the t-quark's mass, the tensor interaction may give a considerable additional contribution into the t-quark's decay. Such deviation from the standard model may be detected increasing the accuracy when measuring of t-quark decay width at Tevatron (CDF and D0 experiments).

In the standard model t-quark decays preferably to b-quark and vector W-boson, which is detected by its decay products. Having in mind that the interaction topology of the new tensor particles with the leptons and quarks is the same as for the gauge W-bosons, the signature of the t-quark decay into b-quark and tensor particle will coincide with the standard case. The tensor interaction, if it is universal, must be relatively weak in order not to appear in other experiments. Therefore the contribution of these new processes in the t-quark decay must be relatively small and may be detected when experimental accuracy is raised.

Up to now a lot of experimental data can be precisely described in the framework of the standard model. However there exist some experiments which show deviation from the standard model. Examples of these experiments are three-particle semileptonic decays of pions and kaons [2, 3]. The obstacles in the interpretation of the experimental data, may be overcome if an additional tensor interaction is introduced [4, 5]. The coupling of this new interaction $G_T = f_T \cdot G_F$ is about two order weaker $f_T \sim 10^{-2}$ than Fermi interaction. Future experiments at Frascati and, maybe, at CERN may shed light on this problem.

This new tensor interaction, if it is universal, may give a contribution also in the leptonic decays of μ-lepton and τ-lepton [6]. Such deviation from the standard model may be observed in precision experiments at TRIUMF and at CERN. The K_L-K_S mass difference sets constraints on the tensor particles masses [7]. The mass of the lightest tensor particle could be less than the t-quark mass (see fig.1). Therefore the lightest tensor particle may give an additional to the W-boson contribution into the t-quark's decay width with the same signature.

In order to estimate the contribution of the new tensor interaction in t-quark decay, we need to learn to calculate diagrams with the new tensor particles. This problem is not solved completely in quantum field theory [8]. However in our simple case of tree-diagrams we can used the diagram technique, which has been developed by Weinberg [9]. Summing up the spin state of the massive tensor particles is performed with the projector operator:

$$P_{\mu\nu\alpha\beta} = (g_{\mu\alpha}g_{\nu\beta} - g_{\nu\alpha}g_{\mu\beta}) - 2\frac{q_\mu q_\alpha g_{\nu\beta} - q_\nu q_\alpha g_{\mu\beta} - q_\mu q_\beta g_{\nu\alpha} + q_\nu q_\beta g_{\mu\alpha}}{q^2}. \tag{1}$$

Summing up the spin state of b-quark and average out the spin state of t-quark is make as usually. Then t-quark's decay width is

$$\Gamma(t \to bT) = f_T \frac{3G_F m_t^3}{\pi\sqrt{2}} \left(1 - \frac{M_T^2}{m_t^2}\right)^2 \left(1 + \frac{M_T^2}{2m_t^2}\right). \tag{2}$$

The contribution of the new tensor particles in t-quark's decay width respectively to standard one are represented as dependence on the mass of the tensor particle on fig.2 .

The initial argument for introducing the tensor interactions was impossibility of interpretation of experimental data for three-particles semileptonic mesons decays in the framework of the standard model. Various supersymmetric extensions of the standard model can not explain these experiments also [10]. Therefore the theoretical investigation of the tensor particle contributions in other physical processes can yields new possibility for the interpretation of the experimental data.

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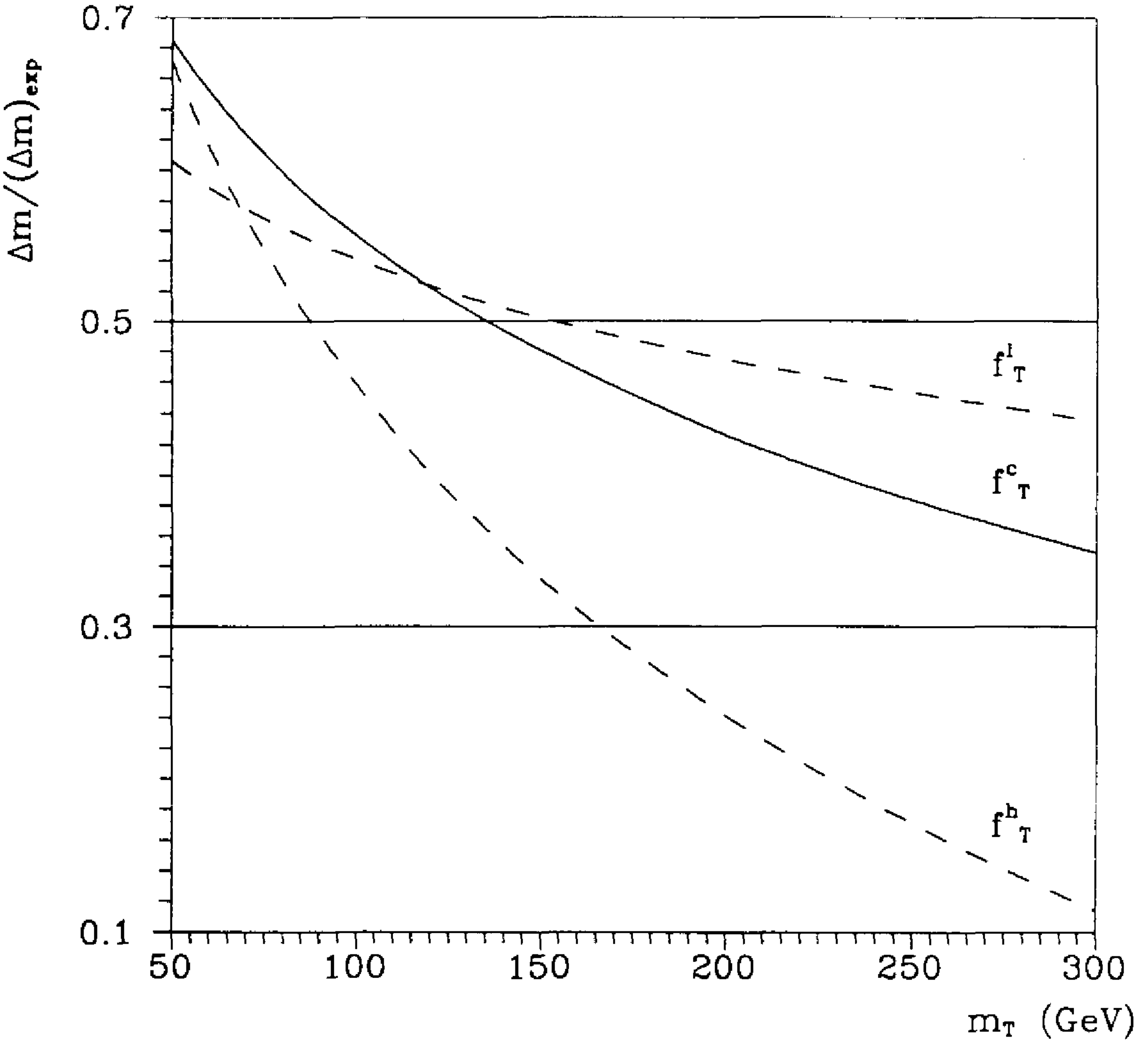

Fig.1

The contribution of the new tensor particles Δm to the K_L-K_S mass difference $(\Delta m)_{exp}$. The three curves show the dependence of the ratio $\Delta m/(\Delta m)_{exp}$ on the mass of lightest tensor particle for different tensor coupling constants (f_T^c is the central value, f_T^h and f_T^l are higher and lower values for 1σ deviation from the central value).

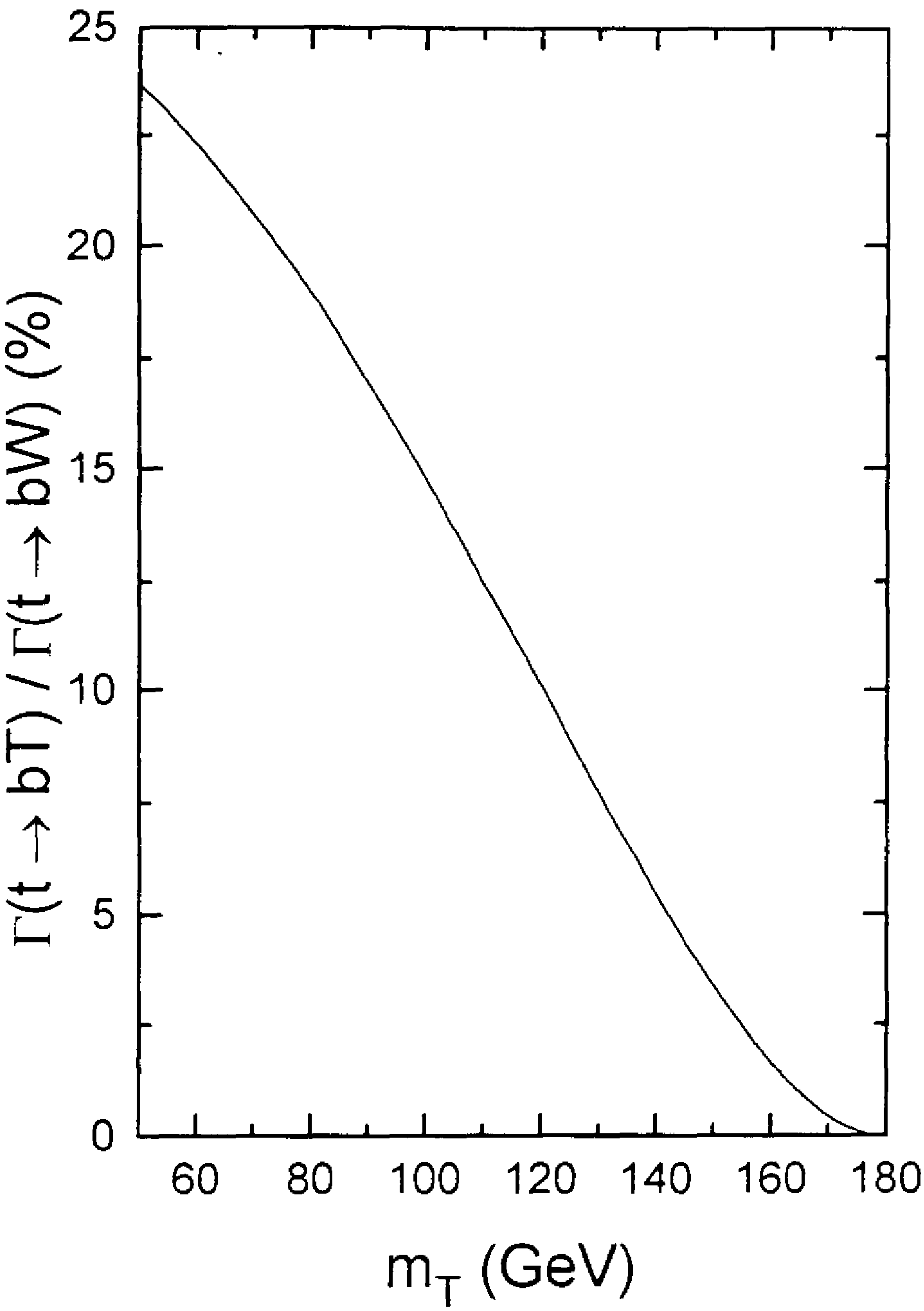

Fig.2

The dependence of new tensor particle contribution to t-quark's decay width on the mass of the lightest tensor particle.