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Ratios of Top Meson Decay Constants

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Abstract

Assuming SU(6)×SU(6) chiral symmetry the ratios of decay constants of pseudoscalar T mesons f_{T_b}/f_{T_b} and f_{T_s}/f_{T_d} and their double ratio have been estimated. They are close to unity and will serve for the study of the strength of mixing of the neutral pseudoscalar mesons and be taken as a prototype of the theory for particles in non-standard region if they exist in nature.

Last summer Oakes [1] has reported that the double ratio $(f_{B_s}/f_{B_d})/(f_{D_s}/f_{D_d})$ be nearly unity with only small corrections under the SU(6)×SU(6) chiral symmetry. The prediction is not yet confirmed experimentally. [2),3)] Even if it holds approximately it seems quite natural to extend that idea up to full scalar and pseudoscalar densities of $(6,\bar{6})+(\bar{6},6)$ representation as far as possible in order to check its physical meaning. We should like to point out that the largeness of the observed mass of t- associated hadron [4] is quite high among the observed hadrons, so this outstanding feature keeps the heaviness of t quark among the heavy triplet in full six members. This observation suggests that the similar conclusion can be obtained from the T meson decay constants. The experimental study for them will be useful for understanding the relative strengths of $T_c-\bar{T}_c$ and $T_u-\bar{T}_u$ mixing. In addition to that the validity of this study will give us a further merit , viz., a kind of scaling character found here will give us a prototype for the theoretical approach on non-standard as well as SUSY particles [5] if they exist in nature.

In the following we shall assume the validity of SU(6)×SU(6) chiral symmetry and neglect the symmetry breaking effect which has been taken into account very detail over many years for light triplet quark associated physics. [6)]

The decay constants are defined as the hadronic matrix elements of quark currents,

$$\langle 0|\bar{d}(x)\gamma^{\mu}\gamma_5 t(x)|T_d(p)\rangle = -i f_{T_d} p^{\mu} e^{ipx} \qquad (1)$$

and

$$\langle 0|\bar{s}(x)\gamma^{\mu}\gamma_5 t(x)|T_s(p)\rangle = -i f_{T_s} p^{\mu} e^{ipx} \qquad (2)$$

with similar relations for the remaining pseudoscalar T-mesons where t quark appears in association with either $\bar{c}$ or $\bar{b}$. The Hamiltonian density and the divergence of the axial currents are given by the same forms as those given in the original paper. [1)]

The ratios of interests can easily be calculated. They take the forms

$$\frac{f_{T_s}}{f_{T_d}} = \left(\frac{M_{T_d}}{M_{T_s}}\right)^2 \frac{m_t + m_s}{m_t + m_d} \frac{\langle 0|\bar{s}\gamma_5 t|T_s\rangle}{\langle 0|d\gamma_5 t|T_d\rangle}, \qquad (3)$$

and

$$\frac{f_{T_b}}{f_{T_c}} = \left(\frac{M_{T_c}}{M_{T_b}}\right)^2 \frac{m_t + m_b}{m_t + m_c} \frac{\langle 0|\bar{b}\gamma_5 t|T_b\rangle}{\langle 0|\bar{c}\gamma_5 t|T_c\rangle}. \qquad (4)$$

The exactness of an analog of Eq.(3) is discussed extensively by Oakes due to the fact that the operators in the matrix elements belong to the same light flavor SU(3) triplet representation and pureness of the state vectors by experience. In Eq.(4) there does not appear any light quarks so its validity should be tested experimentally. However, we believe purely from numerical result that it may be counted as almost equally valid relation.

We shall adopt the same quark masses as the ones used by Oakes for d, s, c and b , viz., m_d=10 MeV, m_s=150 MeV, m_c=1.5 GeV and m_b=5 GeV, while for t we choose it as m_t=176 GeV which seems to be a conservative choice of the observed lower bound found by Fermilab Groups. In the numerical work we

approximate the relevant T meson masses by $M_{T_b} = m_t + m_b$, $M_{T_c} = m_t + m_c$, $M_{T_s} = m_t + m_s$ and $M_{T_d} = m_t$. We find then

$$\frac{f_{T_s}}{f_{T_d}} = 0.999, \tag{5}$$

$$\frac{f_{T_b}}{f_{T_c}} = 0.981 \tag{6}$$

and

$$(f_{T_b}/f_{T_c})/(f_{T_s}/f_{T_d}) = 0.982. \tag{7}$$

One sees that the result in Eq.(5) is much close to 1 relative to the corresponding one found by Oakes for f_{B_s}/f_{B_d}. The ratios in Eqs.(6) and (7) are still close to 1 due to the largeness of m_t. They seem to satisfy qualititively the similar tendency as those found by Oakes but the numerical improvement of the double ratio is not very excellent as that treated by him. For the moment we cannot decide a slight worseness of the approach by this single value but it should be kept in mind how it turns out in other relevant study in relation to future discoveries.

We can expand the double ratio in small masses and mass differences relative to m_t as done by Oakes for an instructive purpose, viz.,

$$(f_{T_b}/f_{T_c})/(f_{T_s}/f_{T_d}) \approx 1 - 2\frac{m_b - m_c}{m_t + m_c} + \frac{m_b - m_c}{m_t} + \frac{m_s - m_d}{m_t}. \tag{8}$$

This confirms again the general tendency for the numerical values found on the ratios in the T-meson decay constants. The main reason of the closeness to the 1 for all the ratios in Eqs.(5)-(7) is not due to the cancellations of the correction terms found in B and D-meson decay constants but to the largeness of the observed mass m_t comparing to the ones for all the remaining quarks.

The important role of the partial conservation of the axial-vector-current hypothesis in light quark sector in the so-called current algebra will naturally be extended to the top hadrons as the effective SU(6)×SU(6) chiral symmetry, by choosing appropriate phenomena where there occur the small energy releases comparing to the top quark mass. At the same time we can apply the perturbative QCD for such problems in general known as the asymptotic freedom. We also expect that the top hadron associated physics will be taken as a prototype, in the sense that it serves as a model construction for a non-standard particle region, which is expected to fill the mass gap between the accelerator energy and a Planck mass scale. Irrespective to these observations a variety of problems on top relevant physics is open by making use of the known approaches.

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References

1) R.J. Oakes, Phys. Rev. Lett. 73(1994), 381.
2) L. Montanet et al., Particle Data Group, Phys. Rev. D50(1994), 1173.
3) J.Z. Bai et al., Phys. Rev. Lett. 74(1995), 4599.
4) F. Abe et al., Phys. Rev. Lett. 74(1995), 2626.
S. Abachi et al., Phys. Rev. Lett. 74(1995), 2632.
5) J. Wess and J. Bagger, Supersymmetry and Supergravity, (Princeton Univ. Press, May, 1982) and ibid., New Chapters and Appendices that will be included in the second edition of the book, Princeton 9009 (June, 1990).
6) H. Leutwyler, Foundations and scope of chiral perturbation theory, Talk given at the Workshop "Chiral Dynamics: Theory and Experiment", July 1994, MIT, BUTP-94/18, and NONPERTURBATIVE METHODS, Rapporteur talk given at the XXVI Int. Conf. on High Energy Physics, Dallas, Aug. 1992, BUTP-92/42.