Light-Front Zero-Mode Issue on the Vector Meson Decay Constant

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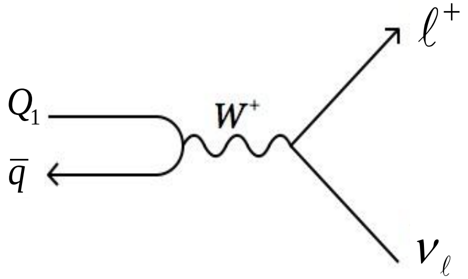
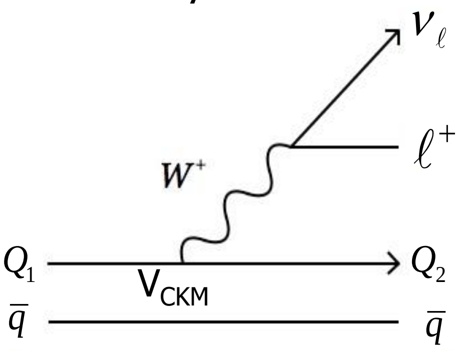
Outline

1. Motivation
   - Zero-mode issue on the vector meson decay constant
2. Comparison of the vector meson decay constant between manifestly covariant model and Light-Front Quark Model(LFQM)
3. LF covariant description of a vector meson decay constant within LFQM
4. Conclusion

1. Motivation

- Decay constants(f) and weak transition form factors(F_i) are two of the most important ingredients in studying weak decays of mesons.





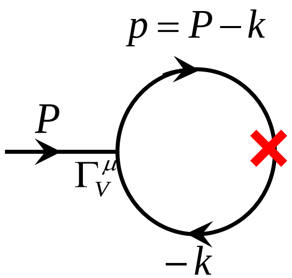
- Light-Front Quark Model (LFQM) based on the LF quantization (Brodsky,Pauli,Pinsky 98) has been quite successful in describing such meson exclusive processes.

- One of the central problems in extracting (f, F_i) is the zero-mode issue in the calculation of the current matrix elements.
e.g.) some weak form factors for P → P(V) and a decay constant of a vector meson
[Jaus 99; Cheng,Chua,Hwang (CCH)04; de Melo, Frederico 97,12; Choi&Ji,PRD80,054016(09);NPA865,95(11); PLB695,518(11)]

In this work, we discuss the zero-mode issues raised by Jaus and find the covariant description of a vector meson decay constant in LFQM.

- Zero-mode issues raised by Jaus[PRD60, 054026 (99)] & Cheng, Chua, and Hwang(CCH) [PRD69, 074025 (04)]

$$\langle 0 | V^{\mu} | V(P,h) \rangle = f_V M \varepsilon^{\mu}(h)$$



$$\Gamma_V^{\mu} = \gamma^{\mu} - \frac{(p-k)^{\mu}}{D}$$

$$\varepsilon^{\mu}(\pm 1) = \left[0, 2\frac{\varepsilon_{\perp}(\pm 1)\cdot \vec{P}_{\perp}}{P^+}, \varepsilon_{\perp}(\pm 1) \right],$$

$$\varepsilon_{\perp}(\pm 1) = \mp \frac{(1, \pm i)}{\sqrt{2}},$$

$$\varepsilon^{\mu}(0) = \frac{1}{M}\left[P^+, \frac{\vec{P}_{\perp}^2 - M^2}{P^+}, \vec{P}_{\perp} \right]$$

1. f_V receives a zero-mode(z.m.) when the plus current(μ=+) with ε(0) is used [Standard LF (SLF) method].

2. One needs to use ε(±) to obtain LF covariant f_v .

3. "It is not clear why the result of f_v depends on the polarization vector."

• In our previous work [Few Body Syst. DOI 10.1007/s00601-012-0535-7 (2013)] , we resolved those issues within the manifestly covariant Bethe-Salpeter(BS) model!

1. f_V receives a zero-mode when the plus current(μ=+) with ε(0) is used [SLF method in LFQM].
   → depends on the choice of vertex factor(e.g. immune to the z.m. for $\Gamma^\mu=\gamma^\mu$!)

2. One needs to use ε(±) to obtain LF covariant f_V .

   → using ε(±) cannot avoid the zero-mode (even at the level of $\Gamma^\mu=\gamma^\mu$!)

3. "It is not clear why the result of f_V depends on the polarization vector."

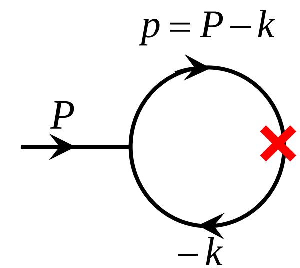
   → f_V [ε(0)]= f_V [ε(±)] if the zero-mode is properly included!

   → Find the exact zero-mode operators in this covariant BS model.

• In this works: we study the applicability of the zero-mode operators found in BS model to a more realistic LFQM.

$$[f_V^{(h=0)}]_{BS} = [f_V^{(h=1)}]_{BS} \quad \Longrightarrow \quad [f_V^{SLF}]_{LFQM}$$

2. Correspondence between BS model and LFQM



- LF covariant method (BS model)
  - Manifestly covariant!
  - Semi-realistic!
  - Off-shell quark propagator!
  - Know how to find the z.m.

- Standard LF(SLF) method (LFQM)
  - Not manifestly covariant!
  - More realistic!
  - On-shell propagator (e.g. Melosh transformation) !
  - Don't know how to find the z.m.

$$\int d^4k\, H_V(p^2)\cdots$$

$$\Downarrow \quad e.g)\, H_V = \frac{g}{(p^2 - \Lambda^2 + i\varepsilon)^n}$$

$$\int [d^3\vec{k}]\chi(x,\vec{k}_\perp)\times[spin]$$

$\int d^4k$ (4D form of φ ??)

$$\Downarrow \longrightarrow \quad \phi(x,k_\perp) = \alpha\exp(-\beta\,\vec{k}^2)$$

or

$$\phi(x,\vec{k}_\perp) = \frac{\alpha}{(1+\beta\,\vec{k}^2)^n}$$

$$\int [d^3\vec{k}]\phi(x,\vec{k}_\perp)\times[spin]$$

Application LFBS model to LFQM by matching $\chi \to \phi$
(i.e. Semi-realistic BS model → More Realistic LFQM)

e.g.) Decay constant of a pseudoscalar meson $\langle 0|\bar{q}\gamma^\mu\gamma_5 q|P(P)\rangle = if_P P^\mu$

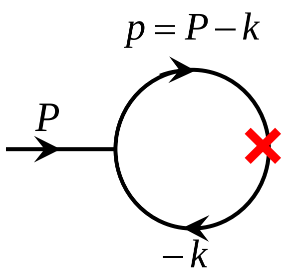
- LF covariant method (BS model)

$$A_h^\mu = N_c\int\frac{d^4k}{(2\pi)^4}\frac{H_V}{N_p N_k}S_h^\mu$$

$$H_V = \frac{g}{(p^2-\Lambda^2+i\varepsilon)^2}$$

$$N_p = p^2 - m_1^2 + i\varepsilon$$

$$N_k = k^2 - m_2^2 + i\varepsilon$$



- SLF method (LFQM)

$$\int[d^3\vec{k}]\phi(x,\vec{k}_\perp)\times[spin]$$

$$\phi(x,\vec{k}_\perp) = \alpha\exp(-\beta\vec{k}^2)$$

$$R^{00}_{\lambda\bar{\lambda}} = -\frac{\bar{u}_\lambda(p_1)\lambda_5 \upsilon_{\bar{\lambda}}(p_2)}{\sqrt{2}\left[M_0^2-(m_1-m_2)^2\right]^{1/2}}$$

$$\sum_{\lambda_q\lambda_{\bar{q}}} R^{JJ_z\dagger}_{\lambda_q\lambda_{\bar{q}}} R^{JJ_z}_{\lambda_q\lambda_{\bar{q}}} = 1$$

$$f_p^{LFBS} = 2N_c\int\frac{dxd^2\vec{k}_\perp}{8\pi^3}\frac{A}{(1-x)}\chi(x,\vec{k}_\perp) \Longleftrightarrow f_p^{SLF} = \sqrt{2N_c}\int\frac{dxd^2\vec{k}_\perp}{8\pi^3}\frac{A}{\sqrt{\vec{k}_\perp^2+A^2}}\phi(x,\vec{k}_\perp)$$

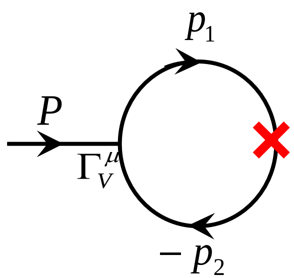
$$A = (1\text{-}x)m_1 + xm_2$$

Correspondence: $\sqrt{2N_c}\frac{\chi}{1-x} \to \frac{\phi}{\sqrt{\vec{k}_\perp^2+A^2}}$ ⇨ $f_p^{LFBS} = f_p^{SLF}$ ⇨ No zero mode!

What about a vector meson? $\langle 0|V^{\mu}|V(P,h)\rangle = f_V M \varepsilon^{\mu}(h)$

- LF covariant method (BS model)

$$A_h^{\mu} = N_c \int \frac{d^4k}{(2\pi)^4} \frac{H_V}{N_p N_k} S_h^{\mu}$$



$$\Gamma_V^{\mu} = \gamma^{\mu} - \frac{(p_1 - p_2)^{\mu}}{D}$$

(Jaus 99)

- SLF method (LFQM)

$$\int [d^3\vec{k}]\phi(x,k_\perp) \times [spin]$$

$$R_{\lambda\bar{\lambda}}^{1J_z} = -\frac{\bar{u}_{\lambda}(p_1)\left[\not{\varepsilon}(J_z) - \frac{\varepsilon\cdot(p_1-p_2)}{D_{LF}}\right]\upsilon_{\bar{\lambda}}(p_2)}{\sqrt{2}\left[M_0^2 - (m_1-m_2)^2\right]^{1/2}}$$

$$\sum_{\lambda_q\lambda_{\bar{q}}} R_{\lambda_q\lambda_{\bar{q}}}^{JJ_z\,\dagger} R_{\lambda_q\lambda_{\bar{q}}}^{JJ_z} = 1$$

$$[f_V^{(h=1)}]_{Full} = \frac{N_c}{4\pi^3}\int_0^1 \frac{dx}{(1-x)} \int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)$$
$$\times \frac{1}{M}\left\{ xM_0^2 - m_1(m_1-m_2) - \vec{k}_\perp^2 + \frac{(m_1+m_2)}{D_{con}}\vec{k}_\perp^2 \right\}$$
$$D_{con} = M + m_1 + m_2$$

(Jaus 99)

⇔

$$f_V^{SLF(h=0)} = \sqrt{2N_c}\int \frac{dx d^2\vec{k}_\perp}{8\pi^3} \frac{\phi(x,\vec{k}_\perp)}{\sqrt{\vec{k}_\perp^2 + A^2}} \left[A + \frac{2\vec{k}_\perp^2}{D_{LF}} \right]$$
$$D_{LF} = M_0 + m_1 + m_2$$

(Jaus 91, Choi&Ji 99)

Type I
Correspondence:

$$\sqrt{2N_c}\,\frac{\chi}{1-x} \to \frac{\phi}{\sqrt{k_\perp^2 + A^2}}$$
$$D_{con} \to D_{LF}$$

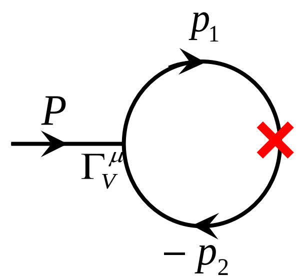
$$[f_V^{(h=1)}]_{Full} \neq f_V^{SLF(h=0)}$$

Right? Wrong?

We shall show in LFQM using φ that

- LF covariant method (BS model)

$$A_h^\mu = N_c \int \frac{d^4k}{(2\pi)^4} \frac{H_V}{N_p N_k} S_h^\mu$$



$$\Gamma_V^\mu = \gamma^\mu - \frac{(p_1-p_2)^\mu}{D}$$

- SLF method (LFQM)

$$\int [d^3\vec{k}]\phi(x,k_\perp)\times[spin]$$

$$R^{1J_z}_{\lambda\bar{\lambda}} = -\frac{\bar{u}_\lambda(p_1)\left[\not\epsilon(J_z) - \frac{\epsilon\cdot(p_1-p_2)}{D_{LF}}\right]\upsilon_{\bar{\lambda}}(p_2)}{\sqrt{2}\left[M_0^2-(m_1-m_2)^2\right]^{1/2}}$$

$$\sum_{\lambda_q\lambda_{\bar{q}}} R^{JJ_z\dagger}_{\lambda_q\lambda_{\bar{q}}} R^{JJ_z}_{\lambda_q\lambda_{\bar{q}}} = 1$$

Wrong!

$$\left[f_V^{(h=1)}\right]_{Full} = \frac{N_c}{4\pi^3 M}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)$$

$$\times\left\{xM_0^2 - m_1(m_1-m_2) - \vec{k}_\perp^2 + \frac{(m_1+m_2)}{D_{con}}\vec{k}_\perp^2\right\}$$

$$D_{con} = M + m_1 + m_2$$

(Jaus 99, CCH 04)

⇔

$$f_V^{SLF(h=0)} = \sqrt{2N_c}\int \frac{dx\,d^2\vec{k}_\perp}{8\pi^3}\frac{\phi(x,\vec{k}_\perp)}{\sqrt{\vec{k}_\perp^2 + A^2}}\left[A + \frac{2\vec{k}_\perp^2}{D_{LF}}\right]$$

$$D_{LF} = M_0 + m_1 + m_2$$

Right!

and in addition… find a new covariant form of f_V

3. Self-consistent covariant form of f_V in LFQM

$$\Gamma_V^\mu = \gamma^\mu - \frac{(p-k)^\mu}{D}$$

(Step 1) LF covariant method (BS model)

- LF cal.

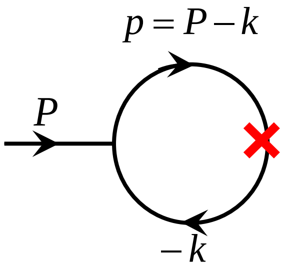
$$A_h^\mu = N_c \int \frac{d^4k}{(2\pi)^4} \frac{H_V}{N_p N_k} S_h^\mu$$

- Manifestly covariant cal.

$$f_V^{Cov}$$

$$f_V^{(h=0)} = \frac{A_{h=0}^+}{M\varepsilon^+(0)}$$

$$f_V^{(h=1)} = \frac{A_{h=1}^\perp \cdot \varepsilon_\perp^*(+)}{M}$$



$$S_h^\mu = Tr[\gamma^\mu(\not{p} + m_1)\Gamma\cdot\varepsilon(h)(-\not{k} + m_2)]$$

$$\Gamma^\alpha = \gamma^\alpha - \frac{(p-k)^\alpha}{D}$$

3. Self-consistent covariant form of f_V in LFQM

(Step 1) LF covariant method (BS model)

$$\Gamma_V^\mu = \gamma^\mu - \frac{(p-k)^\mu}{D}$$

- LF cal.

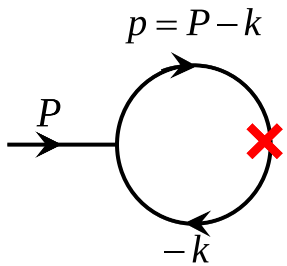
$$A_h^\mu = N_c \int \frac{d^4k}{(2\pi)^4} \frac{H_V}{N_p N_k} S_h^\mu$$

- Manifestly covariant cal.

$$f_V^{Cov}$$

$$f_V^{(h=0)} = \frac{A_{h=0}^+}{M\varepsilon^+(0)}$$

$$f_V^{(h=1)} = \frac{A_{h=1}^\perp \cdot \varepsilon_\perp^*(+)}{M}$$



$$S_h^\mu = Tr[\gamma^\mu (\not p + m_1)\Gamma \cdot \varepsilon(h)(-\not k + m_2)]$$

$$\Gamma^\alpha = \gamma^\alpha - \frac{(p-k)^\alpha}{D}$$

- Valence contribution($0 < k^+ < P^+$, i.e. $k^- = k^-_{on}$)

(i) $\left[f_V^{(h=0)}\right]_{val} = f_V^{Cov}$ when ($\Gamma^\mu = \gamma^\mu$)

(ii) $\left[f_V^{(h=0)}\right]_{val} \neq f_V^{Cov}$ when ($D = D_{con}$)

(i) $\left[f_V^{(h=1)}\right]_{val} \neq f_V^{Cov}$ when ($\Gamma^\mu = \gamma^\mu$)

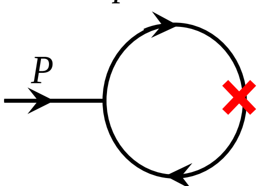
(ii) $\left[f_V^{(h=1)}\right]_{val} \neq f_V^{Cov}$ when ($D = D_{con}$)

➡ $$f_V^{Cov} - \left[f_V^{(h=0)}\right]_{val} \equiv \left[f_V^{(h=0)}\right]_{Z.M.}$$

➡ $$f_V^{Cov} - \left[f_V^{(h=1)}\right]_{val} \equiv \left[f_V^{(h=1)}\right]_{Z.M.}$$

- Method of finding zero-mode operator [Choi & Ji, PRD80,054016(09); NPA 856, 95(11); PLB696, 518(11)]:

$$[f_V^{(h=0)}]_{Full} = \frac{[A^+_{h=0}]_{val} + [A^+_{h=0}]_{Z.M.}}{M\varepsilon^+(0)} = [f_V^{(h=0)}]_{val} + [f_V^{(h=0)}]_{Z.M.}$$



$$\left[A^+_{h=0}\right]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\left\{ \left[S^+_{h=0}\right]_{val} + \left[S^+_{h=0}\right]_{Z.M.} \right\}$$

Zero-mode operator!

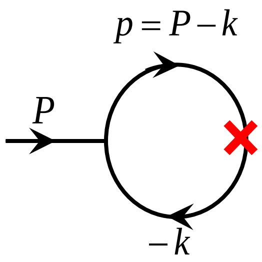
$$\chi(x,k_\perp) = \frac{g}{[x(M^2 - M_0^2)][x^n(M^2 - M_\Lambda^2)^n]}$$

$$M^2_{0(\Lambda)} = \frac{k_\perp^2 + m_1^2(\Lambda^2)}{x} + \frac{k_\perp^2 + m^2}{1-x}$$

$$D_{con} = M + m_1 + m_2$$

• Method of finding zero-mode operator [Choi & Ji, PRD80,054016(09); NPA 856, 95(11); PLB696, 518(11)]:

$$[f_V^{(h=0)}]_{Full} = \frac{[A^+_{h=0}]_{val} + [A^+_{h=0}]_{Z.M.}}{M\varepsilon^+(0)} = [f_V^{(h=0)}]_{val} + [f_V^{(h=0)}]_{Z.M.}$$



$$[A^+_{h=0}]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\left\{ [S^+_{h=0}]_{val} + [S^+_{h=0}]_{Z.M.} \right\}$$

Zero-mode operator!

$$\chi(x,k_\perp) = \frac{g}{[x(M^2-M_0^2)][x^n(M^2-M_\Lambda^2)^n]}$$

$$M^2_{0(\Lambda)} = \frac{k_\perp^2 + m_1^2(\Lambda^2)}{x} + \frac{k_\perp^2 + m^2}{1-x}$$

$$D_{con} = M + m_1 + m_2$$

Step1) Find the (singular) term proportional to p^- (or 1/x) in S^μ_h as x →0 when $p^- = p^-_{on}$.

$$\lim_{x\to 0} S^+_{h=0}(p^- = p^-_{on}) = 4\frac{\varepsilon^+(0)}{D_{con}} m_1 p^-$$

Step2) Replace $p^- \to -Z_2$ [Jaus 99, Choi&Ji 09,11]

$$[S^+_{h=0}]_{Z.M.} = 4\frac{\varepsilon^+(0)}{D_{con}} m_1(-Z_2)$$

where

$$Z_2 = x(M^2 - M_0^2) + m_1^2 - m^2 + (1-2x)M^2$$

• Method of finding zero-mode operator [Choi & Ji, PRD80,054016(09); NPA 856, 95(11); PLB696, 518(11)]:

$$[f_V^{(h=1)}]_{Full} = \frac{([A^{\perp}_{h=1}]_{val} + [A^{+}_{h=0}]_{Z.M.})\cdot \varepsilon^{*}_{\perp}(+)}{M} = [f_V^{(h=1)}]_{val} + [f_V^{(h=1)}]_{Z.M.}$$

$$[A^{\perp}_{h=1}]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\left\{ [S^{\perp}_{h=1}]_{val} + [S^{\perp}_{h=1}]_{Z.M.} \right\}$$

Zero-mode operator!

$$[S^{\perp}_{h=1}]_{Z.M.} = 2(-Z_2)\varepsilon_\perp(+)$$

We find from the covariant BS model that

$$(a)\ [f_V^{(h=0)}]_{Full} = [f_V^{(h=1)}]_{Full} = f_V^{Cov}$$

$$(b)\ [f_V^{(h=0)}]_{val} = [f_V^{(h=0)}]_{on}$$

$$(c)\ [f_V^{(h=1)}]_{val} = [f_V^{(h=1)}]_{on} + [f_V^{(h=1)}]_{off}$$

$\to 0$ as $M \to M_0$

(Step 2) Check if the zero mode found in BS model can be applicable to LFQM with φ

$$[f_V^{(h=0)}]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\left\{ [S^+_{h=0}]_{val} + [S^+_{h=0}]_{Z.M.} \right\}$$

$$[f_V^{(h=1)}]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\frac{1}{M}\left\{ [S^\perp_{h=1}]_{val} + [S^\perp_{h=1}]_{Z.M.} \right\}\cdot \varepsilon^*_\perp(+)$$

Type I Correspondence (Jaus's prescription):

$$\sqrt{2N_c}\,\frac{\chi}{1-x} \to \frac{\phi}{\sqrt{k_\perp^2 + A^2}}$$

$$D_{con} \to D_{LF}$$

⇒ $[f_V^{(h=1)}]_{Full} \neq f_V^{SLF}$

⇓

$$[f_V^{(h=0)}]_{Full} \overset{?}{=} [f_V^{(h=1)}]_{Full}$$

(Step 2) Check if the zero mode found in BS model can be applicable to LFQM with φ

$$\left[f_V^{(h=0)}\right]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\left\{ \left[S^+_{h=0}\right]_{val} + \left[S^+_{h=0}\right]_{Z.M.} \right\}$$

$$\left[f_V^{(h=1)}\right]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\frac{1}{M}\left\{ \left[S^\perp_{h=1}\right]_{val} + \left[S^\perp_{h=1}\right]_{Z.M.} \right\}\cdot \varepsilon^*_\perp(+)$$

Type I
Correspondence
(Jaus's prescription):

$$\sqrt{2N_c}\,\frac{\chi}{1-x} \to \frac{\phi}{\sqrt{k_\perp^2 + A^2}}$$

$$D_{con}(=M+m_1+m_2) \to D_{LF}(=M_0+m_1+m_2)$$

$$[f_V^{(h=0)}]_{Full} \neq [f_V^{(h=1)}]_{Full} \neq f_V^{SLF}$$

Jaus's formula doesn't satisfy the covariance!

(Step 2) Check if the zero mode found in BS model can be applicable to LFQM with φ

$$\left[f_V^{(h=0)}\right]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\left\{ \left[S^+_{h=0}\right]_{val} + \left[S^+_{h=0}\right]_{Z.M.} \right\}$$

$$\left[f_V^{(h=1)}\right]_{Full} = \frac{N_c}{16\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)\frac{1}{M}\left\{ \left[S^\perp_{h=1}\right]_{val} + \left[S^\perp_{h=1}\right]_{Z.M.} \right\}\cdot \varepsilon^*_\perp(+)$$

Type II
Correspondence
(Our prescription):

$$\sqrt{2N_c}\frac{\chi}{1-x} \rightarrow \frac{\phi}{\sqrt{k_\perp^2 + A^2}}$$

$$B.E. = (M - M_0) \rightarrow 0$$

⇓

$$[f_V^{(h=0)}]_{Full} = [f_V^{(h=1)}]_{Full} = f_V^{SLF}$$

$$= [f_V^{(h=1)}]_{on}$$

$$\left[f_V^{(h=0)}\right]_{Full} = \frac{N_c}{4\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)$$

$$\times\frac{1}{M}\left\{x(1-x)M^2+\vec{k}_\perp^2+m_1m_2+x(m_1+m_2)\frac{[\vec{k}_\perp^2+m_2^2-(1-x)^2M^2]}{(1-x)D_{con}}\right\}$$

$$\left[f_V^{(h=1)}\right]_{on} = \frac{N_c}{4\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)$$

$$\times\frac{1}{M}\left\{\frac{\vec{k}_\perp^2+A^2}{2x(1-x)}-\vec{k}_\perp^2+\frac{(m_1+m_2)}{D_{con}}\vec{k}_\perp^2\right\}$$

$$\left[f_V^{(h=1)}\right]_{Full} = \frac{N_c}{4\pi^3}\int_0^1 \frac{dx}{(1-x)}\int d^2\vec{k}_\perp \chi(x,\vec{k}_\perp)$$

$$\times\frac{1}{M}\left\{xM_0^2-m_1(m_1-m_2)-\vec{k}_\perp^2+\frac{(m_1+m_2)}{D_{con}}\vec{k}_\perp^2\right\}$$

$$f_V^{SLF(h=0)} = \sqrt{2N_c}\int\frac{dx\,d^2\vec{k}_\perp}{8\pi^3}\frac{\phi(x,\vec{k}_\perp)}{\sqrt{\vec{k}_\perp^2+A^2}}\left[A+\frac{2\vec{k}_\perp^2}{D_{LF}}\right]$$

• Decay constants(in unit of MeV)

		$f_{full}^{(h=0)}$	$f_{on}^{(h=1)}$	$f_{full}^{(h=1)}$	f^{SLF}
ρ	Type I	304	369	369	246
	Type II	[246]	[246]	[246]	
K*	I	322	389	389	256
	II	[256]	[256]	[256]	
D*	I	274	322	322	239
	II	[239]	[239]	[239]	
J/ψ	I	429	486	486	360
	II	[360]	[360]	[360]	

Jaus's prescription: $f_{full}^{(h=1)}$ with Type I
[PRD60,054026(99)]

⟺

Our LFQM: f^{SLF}
[PRD75,034019(07); PRD75,073016(07)]

• Decay constants(in unit of MeV)

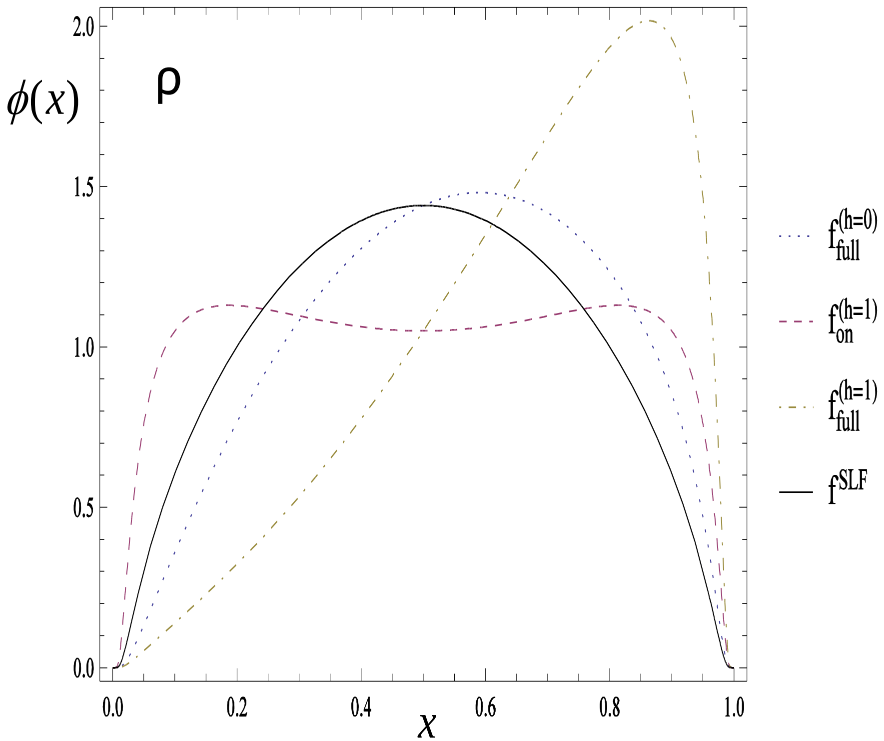
	$f_{full}^{(h=0)}$	$f_{on}^{(h=1)}$	$f_{full}^{(h=1)}$	f^{SLF}
ρ Type I	304	369	369	246
Type II	[246]	[246]	[246]	
K* I	322	389	389	256
II	[256]	[256]	[256]	
D* I	274	322	322	239
II	[239]	[239]	[239]	
J/ψ I	429	486	486	360
II	[360]	[360]	[360]	

(Step 3) Further constraint

		$f_{full}^{(h=0)}$	$f_{on}^{(h=1)}$	$f_{full}^{(h=1)}$	f^{SLF}
ρ	Type I	304	369	369	246
	Type II	[246]	[246]	[246]	
K*	I	322	389	389	256
	II	[256]	[256]	[256]	
D*	I	274	322	322	239
	II	[239]	[239]	[239]	
J/ψ	I	429	486	486	360
	II	[360]	[360]	[360]	

Quark Distribution Amplitudes(DAs)

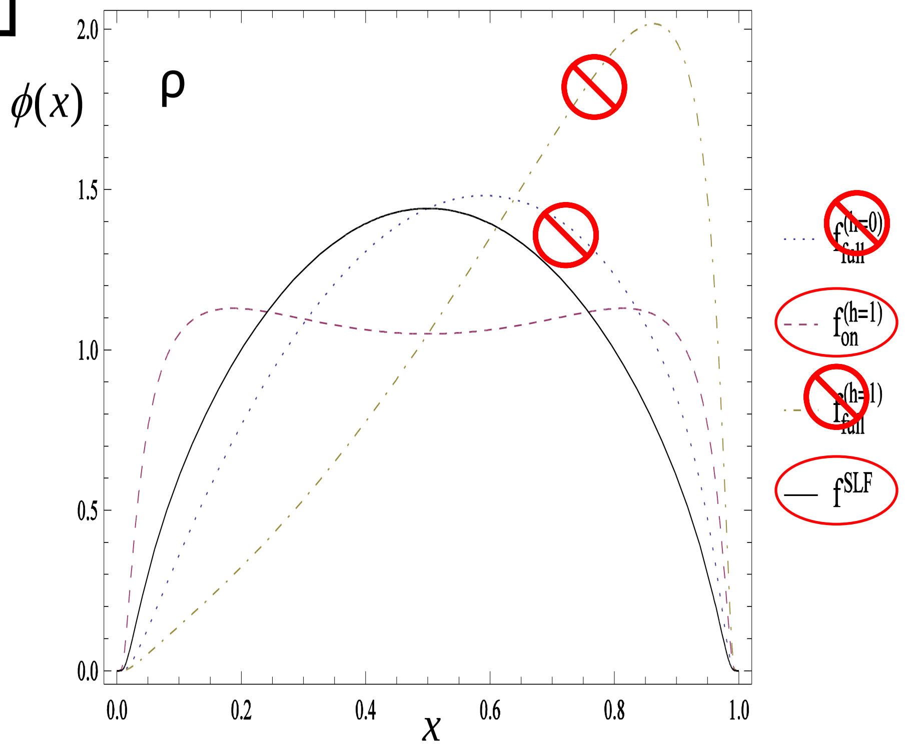
$$\int_0^1 \phi(x)dx = \frac{f_V}{2\sqrt{6}}$$



		$f_{full}^{(h=0)}$	$f_{on}^{(h=1)}$	$f_{full}^{(h=1)}$	f^{SLF}
ρ	Type I Type II	304 [246]	369 [246]	369 [246]	246
K*	I II	322 [256]	389 [256]	389 [256]	256
D*	I II	274 [239]	322 [239]	322 [239]	239
J/ψ	I II	429 [360]	486 [360]	486 [360]	360

Quark Distribution Amplitudes(DAs)

$$\int_0^1 \phi(x)dx = \frac{f_V}{2\sqrt{6}}$$

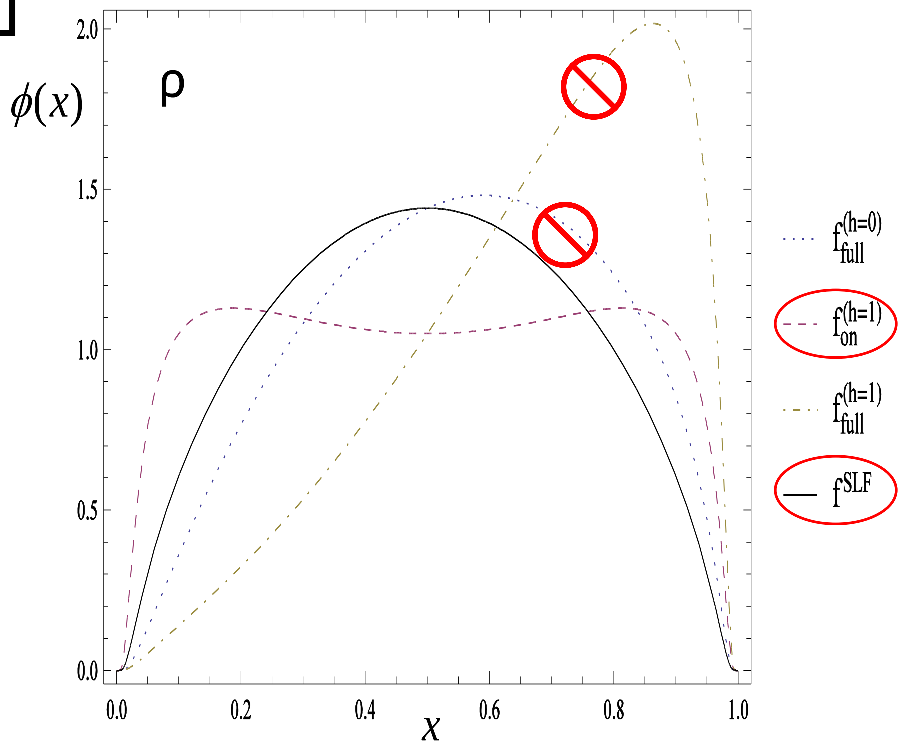


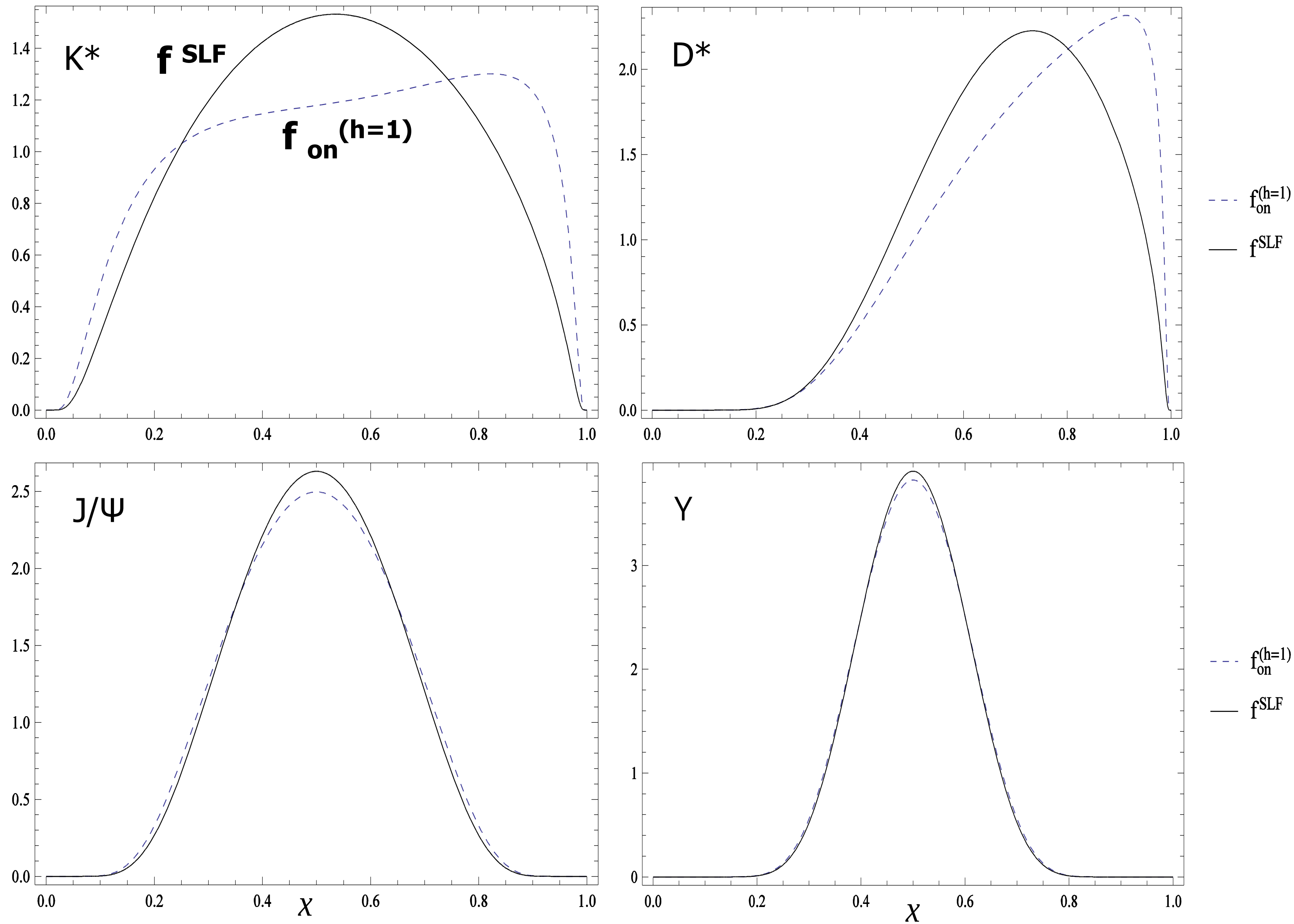
		$f_{full}^{(h=0)}$	$f_{on}^{(h=1)}$	$f_{full}^{(h=1)}$	f^{SLF}
ρ	Type I	304	369	369	246
	Type II	[246]	[246]	[246]	
K*	I	322	389	389	256
	II	[256]	[256]	[256]	
D*	I	274	322	322	239
	II	[239]	[239]	[239]	
J/ψ	I	429	486	486	360
	II	[360]	[360]	[360]	

Quark Distribution Amplitudes(DAs)

$$\int_0^1 \phi(x)dx = \frac{f_V}{2\sqrt{6}}$$

Play the role of very good Constraints!





K*
f SLF
f on(h=1)
D*
J/Ψ
Υ
x
x
f_on^(h=1)
f^SLF
f_on^(h=1)
f^SLF

4.Conclusions

In this work, we investigated a vector meson decay constant f_V in both manifestly covariant model and more realistic LFQM.

1. We computed f_V using (J^+, $\varepsilon(0)$) and ($J^\perp$, $\varepsilon(+)$) and check the LF covariance of it.

   - We have found in the manifestly covariant model that

     - *f_V is independent of the polarization vectors if the zero-modes are properly included!*

   - Jaus's Type I replacement of the LF vertex function in covariant model with the gaussian w.f. shows that the two combinations give different results.

     - Jaus's form of decay constant is incorrect for more realistic LFQM using gaussian w.f.

2. We find a self-consistent covariant description of f_V in a more realistic LFQM
   - $f^{(h=1)}_{on}$ with type II replacement and f^{SLF} satisfy the consistency of the model
   - the quark DA plays an important constraint to check the validity of the model