半轻粲味介子衰变

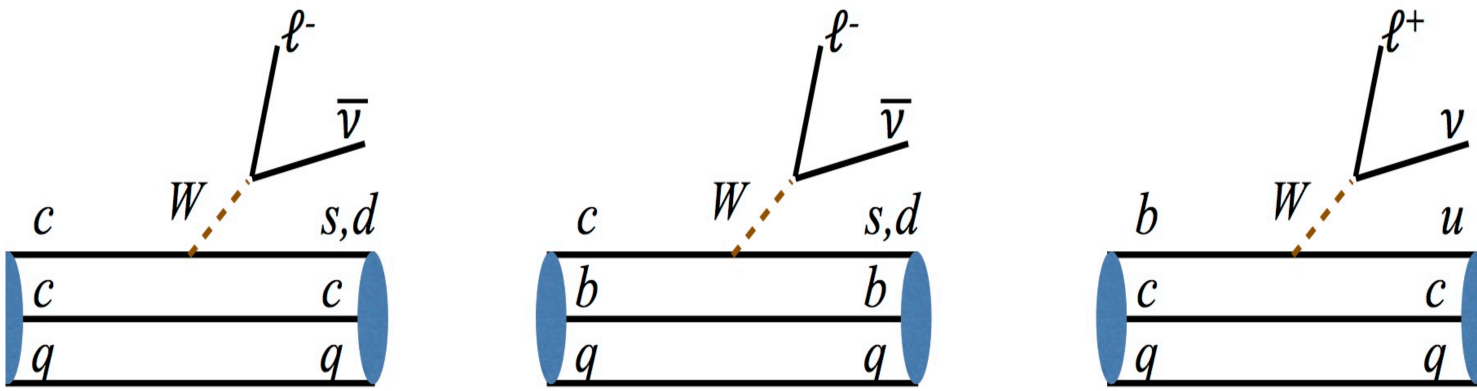
王 伟

上海交通大学

2017年9月24日 南开大学

BESIII-BELLE-LHCb粲强子物理联合研讨会

2. Semi-leptonic decays



Key point is to calculate form factors

First try in the light-front quark model

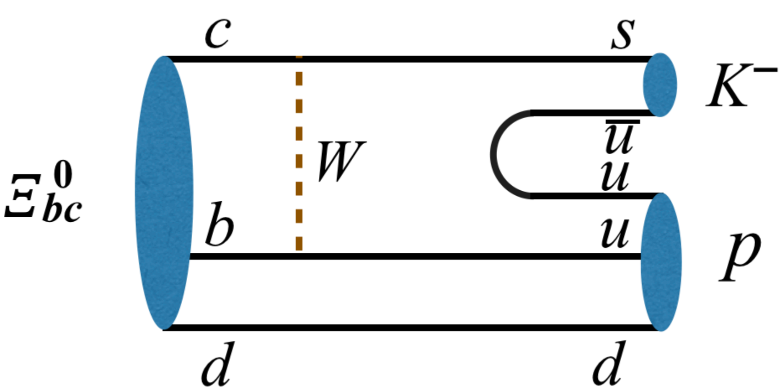
Wei Wang, Fu-Sheng Yu, Zhen-Xing Zhao

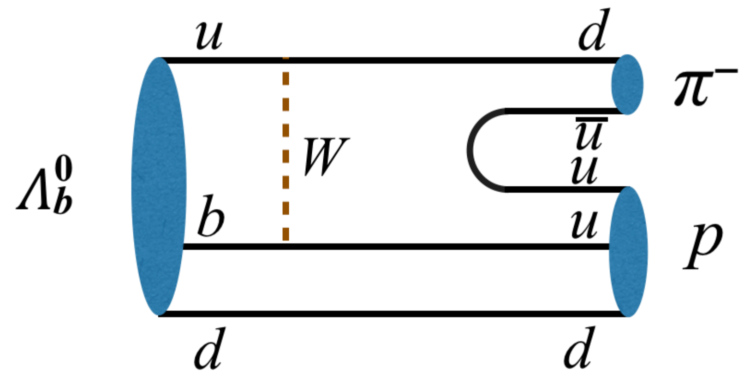
From Prof. Lu's slides

LHCb 物理理论与实验问题研讨会

Workshop on LHCb Physics 2016 Wuhan

2016 年 4 月 21-23 日,中国武汉


c
s
K^-
$\bar{u}$
u
W
Ξ_{bc}^0
b
u
p
d
d


u
d
π^-
$\bar{u}$
u
W
Λ_b^0
b
u
p
d
d

Weak Decays of Doubly Heavy Baryon : $\Xi^0_{bc} \to pK^-$ and $\Xi^+_{cc} \to \Sigma_{++c}K^-$

R.H. Li, C.D.Lu, W.Wang, F.S.Yu, Z.T. Zou

Weak Decays of Doubly Heavy Baryon :
the sequel

- Spectroscopy
- decay constant
- lifetime
- SU(3) Analysis
- 1/2→1/2 case
- FCNC channels
- 1/2→3/2 case
- Light quark decay

Observation of the doubly charmed baryon Ξ_{cc}^{++}

Phys.Rev.Lett. 119, 112001 (2017)

LHCb collaboration†

Abstract

A highly significant structure is observed in the $\Lambda_c^+ K^- \pi^+ \pi^+$ mass spectrum, where the Λ_c^+ baryon is reconstructed in the decay mode $pK^-\pi^+$. The structure is consistent with originating from a weakly decaying particle, identified as the doubly charmed baryon Ξ_{cc}^{++}. The mass, measured relative to that of the Λ_c^+ baryon, is found to be $3621.40 \pm 0.72\,(\mathrm{stat}) \pm 0.27\,(\mathrm{syst}) \pm 0.14\,(\Lambda_c^+)\,\mathrm{MeV}/c^2$, where the last uncertainty is due to the limited knowledge of the Λ_c^+ mass. The state is observed in a sample of proton-proton collision data collected by the LHCb experiment at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of $1.7\,\mathrm{fb}^{-1}$, and confirmed in an additional sample of data collected at 8 TeV.

上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

Weak Decays of Doubly Heavy Baryon : $\Xi^0_{bc} \to pK^-$ and $\Xi^+_{cc} \to \Sigma_{++c}K^-$

R.H. Li, C.D.Lu, W.Wang, F.S.Yu, Z.T. Zou

Weak Decays of Doubly Heavy Baryons: the 1/2→1/2 case

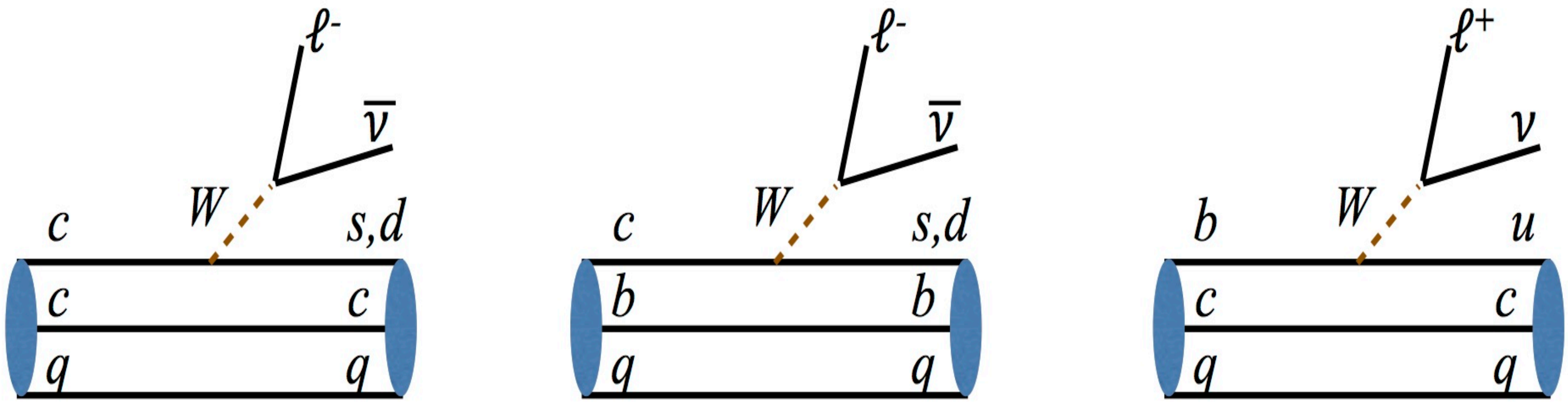
Weak Decays of Doubly Heavy Baryons: the SU(3) Analysis

Weak Decays of Doubly Heavy Baryons: decay constant

Weak Decays of Doubly Heavy Baryons: lifetime

Weak Decays of Doubly Heavy Baryons: the FCNC channels

Weak Decays of Doubly Heavy Baryons: the 1/2→3/2 case

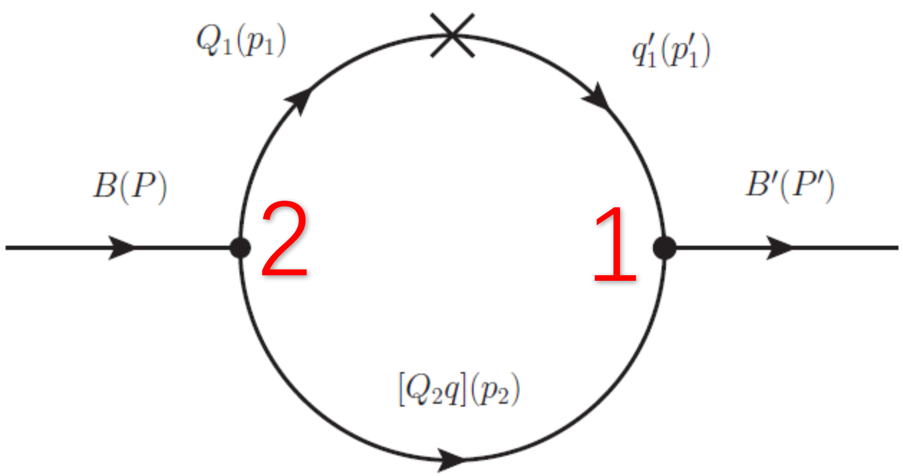


Quark-diquark picture *1707,02834,W.Wang, F.S.Yu, Z.X. Zhao*

形状因子的计算

$$\langle B'(P',S'_z)|(V-A)_\mu|B(P,S_z)\rangle = \int\{d^3p_2\}\frac{\phi'^*(x',k'_\perp)\phi(x,k_\perp)}{2\sqrt{p_1^+p_1'^+(p_1\cdot\bar{P}+m_1M_0)(p'_1\cdot\bar{P}'+m'_1M'_0)}}$$
$$\times\,\bar{u}(\bar{P}',S'_z)\bar{\Gamma}'(\not p'_1+m'_1)\gamma_\mu(1-\gamma_5)(\not p_1+m_1)\Gamma u(\bar{P},S_z)$$

1 2



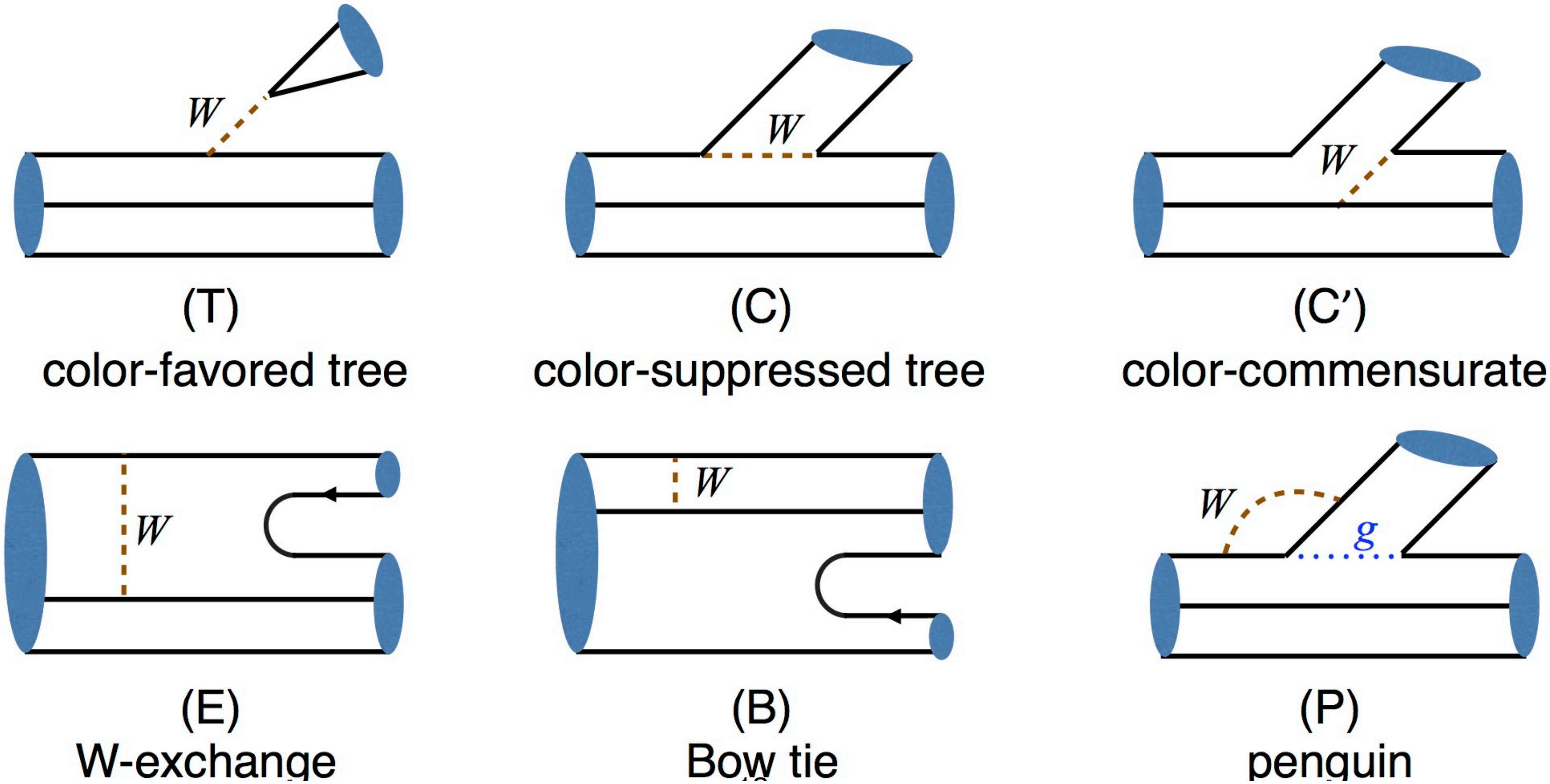
双粲重子的半轻衰变

channels	$\Gamma/$ GeV	$\mathcal{B}$	Γ_L/Γ_T
$\Xi_{cc}^{++} \to \Lambda_c^+ l^+ \nu_l$	1.08×10^{-14}	4.93×10^{-3}	8.50
$\Xi_{cc}^{++} \to \Sigma_c^+ l^+ \nu_l$	9.88×10^{-15}	4.50×10^{-3}	1.27
$\Xi_{cc}^{++} \to \Xi_c^+ l^+ \nu_l$	1.18×10^{-13}	5.39×10^{-2}	9.98
$\Xi_{cc}^{++} \to \Xi_c^{\prime +} l^+ \nu_l$	1.32×10^{-13}	6.01×10^{-2}	1.41
$\Xi_{cc}^{+} \to \Sigma_c^0 l^+ \nu_l$	1.97×10^{-14}	2.99×10^{-3}	1.27
$\Xi_{cc}^{+} \to \Xi_c^0 l^+ \nu_l$	1.17×10^{-13}	1.77×10^{-2}	9.98
$\Xi_{cc}^{+} \to \Xi_c^{\prime 0} l^+ \nu_l$	1.31×10^{-13}	1.99×10^{-2}	1.42
$\Omega_{cc}^{+} \to \Xi_c^0 l^+ \nu_l$	5.42×10^{-15}	2.22×10^{-3}	9.14
$\Omega_{cc}^{+} \to \Xi_c^{\prime 0} l^+ \nu_l$	6.07×10^{-15}	2.49×10^{-3}	1.34
$\Omega_{cc}^{+} \to \Omega_c^0 l^+ \nu_l$	1.62×10^{-13}	6.65×10^{-2}	1.46

D^+ DECAY MODES

$\overline{K}^0 e^+ \nu_e$	(8.82±0.13) %	869
$\overline{K}^0 \mu^+ \nu_\mu$	(8.74±0.19) %	865

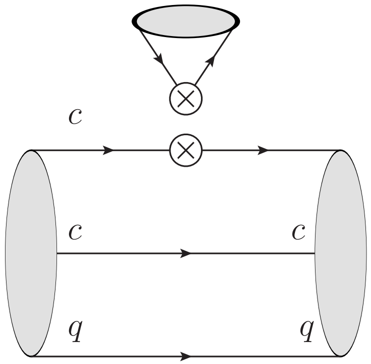
非轻衰变

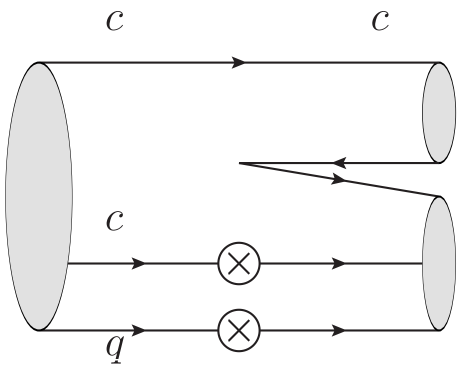


Weak Decays of Doubly Heavy Baryons: the SU(3) Analysis

W. Wang, J. Xu, Z.P.Xing, 1707.06570

SU(3)分析





- Decays into a charmed baryon and a light meson
- Decays into a light octet baryon and a charmed meson
- Decays into a light decuplet baryon and a charmed meson

SU(3)分析

宽度关系：

$$\Gamma(\Xi_{cc}^{++} \to \Lambda_c^+ \pi^+) = \Gamma(\Xi_{cc}^{++} \to \Xi_c^+ K^+),$$
$$\Gamma(\Xi_{cc}^{+} \to \Xi_c^+ K^0) = \Gamma(\Omega_{cc}^{+} \to \Lambda_c^+ \overline{K}^0),$$
$$\Gamma(\Omega_{cc}^{+} \to \Xi_c^0 \pi^+) = \Gamma(\Xi_{cc}^{+} \to \Xi_c^0 K^+).$$

$$\Gamma(\Xi_{cc}^{++} \to \Sigma_c^{++} \pi^0) = \frac{1}{3}\Gamma(\Xi_{cc}^{++} \to \Sigma_c^{++} \eta),$$
$$\Gamma(\Xi_{cc}^{++} \to \Sigma_c^{+} \pi^+) = \Gamma(\Xi_{cc}^{++} \to \Xi_c'^{+} K^+),$$
$$\Gamma(\Xi_{cc}^{+} \to \Sigma_c^{++} \pi^-) = \Gamma(\Omega_{cc}^{+} \to \Sigma_c^{++} K^-),$$
$$\Gamma(\Xi_{cc}^{+} \to \Sigma_c^{0} \pi^+) = \Gamma(\Omega_{cc}^{+} \to \Omega_c^{0} K^+),$$
$$\Gamma(\Xi_{cc}^{+} \to \Xi_c'^{+} K^0) = \Gamma(\Omega_{cc}^{+} \to \Sigma_c^{+} \overline{K}^0),$$
$$\Gamma(\Omega_{cc}^{+} \to \Xi_c'^{0} \pi^+) = \Gamma(\Xi_{cc}^{+} \to \Xi_c'^{0} K^+).$$

Global fit in future?

双重重子寿命

literature	Ξ_{cc}^{++}	Ξ_{cc}^{+}	Ω_{cc}^{+}
Karliner, Rosner, 2014	185	53	
Kiselev, Likhoded, 1998	430 ± 100	110 ± 10	
Kiselev, Likhoded,2002	460 ± 50	160 ± 50	270 ± 60
Guberina, Melic, Stefancic, 1998	1550	220	250
Chang, Li, Li, Wang, 2007	670	250	210

$$\tau(\Xi_{cc}^{++}) \gg \tau(\Xi_{cc}^{+}) \sim \tau(\Omega_{cc})$$

D-mesons

	$D^0 = (\bar{u}c)$	$D^+ = (\bar{d}c)$	$D_s^+ = (\bar{s}c)$
Mass (GeV)	1.86491(17)	1.8695(4)	1.9690(14)
Lifetime (ps)	0.4101(15)	1.040(7)	0.500(7)
$\tau(X)/\tau(D^0)$	1	2.536 ± 0.017	1.219 ± 0.017

$$\frac{\tau(D^+)}{\tau(D^0)}^{\text{HQE 2013}} = 2.2 \pm 0.4^{(\text{hadronic})}{}^{+0.03(\text{scale})}_{-0.07},$$

$$\frac{\tau(D_s^+)}{\tau(D^0)}^{\text{HQE 2013}} = 1.19 \pm 0.12^{(\text{hadronic})}{}^{+0.04(\text{scale})}_{-0.04},$$

A. Lenz, T. Rauh, 1305.3588

双重重子寿命的计算

- 算符展开

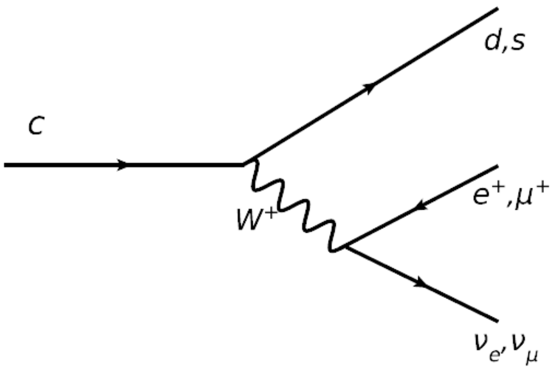
$$\hat{T} = \mathrm{T}\left[iH_{eff}(x), H_{eff}(0)\right]$$

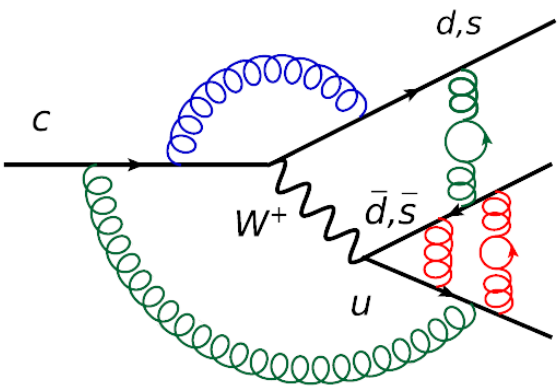
$$\Gamma(H_Q \to X) = \frac{1}{2m_{H_Q}} \mathrm{Im} \int d^4x \langle H_Q|\hat{T}|H_Q\rangle = \frac{1}{2m_{H_Q}} \langle H_Q|\hat{\Gamma}|H_Q\rangle,$$

?

$$\Gamma(H_Q \to X) \;=\; \frac{G_F^2 m_c^5}{192\pi^3}|V_{\mathrm{CKM}}|^2 \left(c_3 \frac{\langle H_c|\bar{c}c|H_c\rangle}{2m_{H_Q}} + c_5 \frac{\langle H_c|\bar{c}i\sigma_{\mu\nu}G^{\mu\nu}c|H_c\rangle}{2m_{H_Q}m_c^2} + c_6^i \frac{\langle H_c|(\bar{c}\Gamma_i q)(\bar{q}\Gamma_i c)|H_c\rangle}{2m_{H_Q}m_c^3} \right)$$

$$\Gamma_c = \frac{G_F^2 m_c^5}{192\pi^3}|V_{cs}|^2 c_{3,c}$$





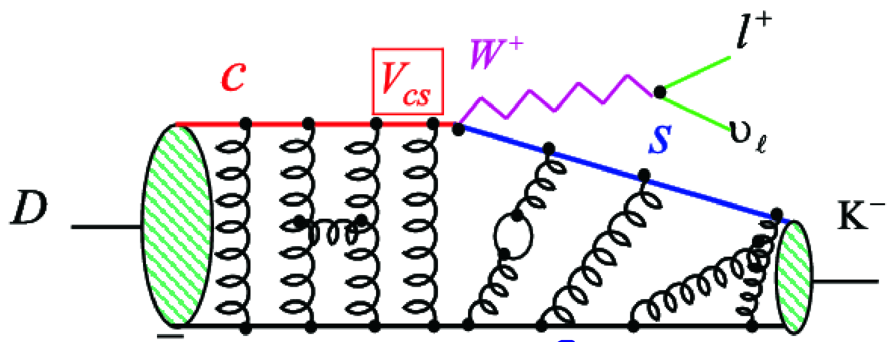
半轻D介子衰变

- $D \to P_1 P_2 l\nu$

- Why $D \to P_1 P_2 l\nu$?

- Theoretical Analysis

D->Pl ν & D->Vl ν



$$\mathcal{M}(D \to P\ell^+\overline{\nu}_\ell) = -i\frac{G_F}{\sqrt(2)} V_{qq'} L^\mu H_\mu$$

- Hadronic current ($q^2 = (p_\ell + p_{\overline{\nu}_\ell})^2$) in case of D decays to pseudoscalar meson

  $$\langle P(p_f)|V^\mu|D(p_i)\rangle =$$
  $$f_+(q^2)\left((p_i + p_f)^\mu - \frac{m_D^2 - m_P^2}{q^2}(p_i - p_f)^\mu\right) + f_0(q^2)\frac{m_D^2 - m_P^2}{q^2}(p_i - p_f)^\mu$$

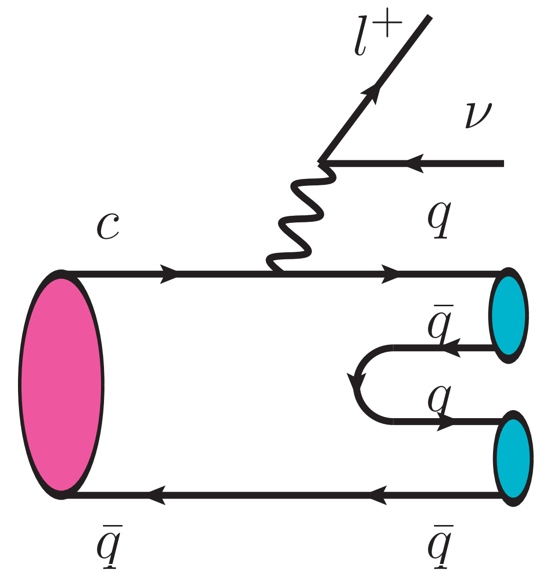
  - $f_+(q^2)$ and $f_0(q^2)$ are form factors
  - neglecting the lepton mass only one form factor contributes

  $$\frac{d\Gamma}{dq^2} = \frac{G_F^2}{24\pi^3}|V_{cq}|^2|p_P(q^2)|^3 f_+^P(q^2)$$

见刘朝峰报告

- Extract CKM matrix elements and test of LQCD calculations

D->$P_1P_2l\nu$



$\overline{K}^0 e^+ \nu_e$	(8.90 ± 0.15) %		869
$\overline{K}^0 \mu^+ \nu_\mu$	(9.3 ± 0.7) %		865
$K^- \pi^+ e^+ \nu_e$	(3.91 ± 0.11) %		864
$\overline{K}^*(892)^0 e^+ \nu_e$, $\overline{K}^*(892)^0 \to K^- \pi^+$	(3.68 ± 0.10) %		722
$(K^- \pi^+)_{S-wave} e^+ \nu_e$	$(2.26 \pm 0.11) \times 10^{-3}$		–
$\overline{K}^*(1410)^0 e^+ \nu_e$, $\overline{K}^*(1410)^0 \to K^- \pi^+$	$< 6 \times 10^{-3}$	CL=90%	–
$\overline{K}_2^*(1430)^0 e^+ \nu_e$, $\overline{K}_2^*(1430)^0 \to K^- \pi^+$	$< 5 \times 10^{-4}$	CL=90%	–
$K^- \pi^+ e^+ \nu_e$ nonresonant	$< 7 \times 10^{-3}$	CL=90%	864
$K^- \pi^+ \mu^+ \nu_\mu$	(3.9 ± 0.4) %		851
$\overline{K}^*(892)^0 \mu^+ \nu_\mu$, $\overline{K}^*(892)^0 \to K^- \pi^+$	(3.52 ± 0.10) %		717
$K^- \pi^+ \mu^+ \nu_\mu$ nonresonant	$(2.1 \pm 0.5) \times 10^{-3}$		851
$K^- \pi^+ \pi^0 \mu^+ \nu_\mu$	$< 1.6 \times 10^{-3}$	CL=90%	825
$\pi^0 e^+ \nu_e$	$(4.05 \pm 0.18) \times 10^{-3}$		930
$\eta e^+ \nu_e$	$(1.14 \pm 0.10) \times 10^{-3}$		855
$\rho^0 e^+ \nu_e$	$(2.18^{+0.17}_{-0.25}) \times 10^{-3}$		774
$\rho^0 \mu^+ \nu_\mu$	$(2.4 \pm 0.4) \times 10^{-3}$		770
$\omega e^+ \nu_e$	$(1.69 \pm 0.11) \times 10^{-3}$		771
$\eta'(958) e^+ \nu_e$	$(2.2 \pm 0.5) \times 10^{-4}$		689
$\phi e^+ \nu_e$	$< 1.3 \times 10^{-5}$	CL=90%	657

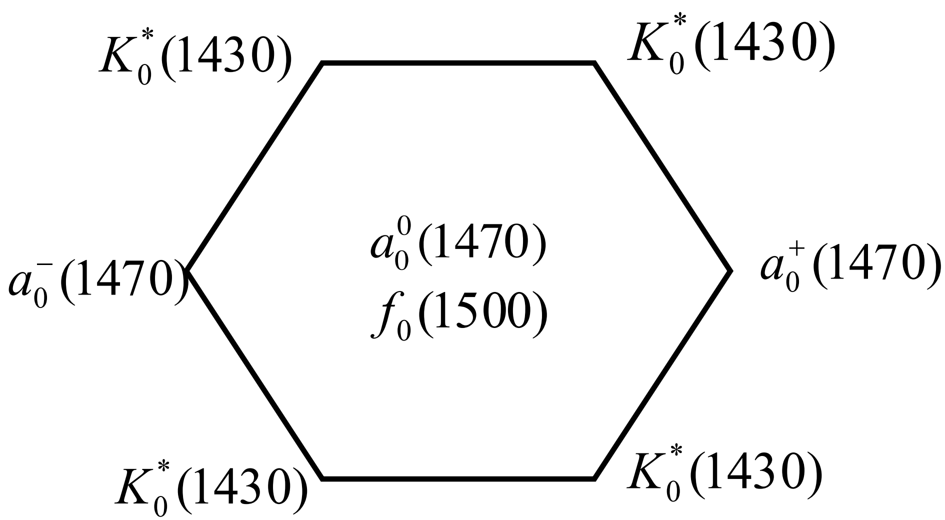
$$H = D.P.P.\lambda_p + D.\lambda_p \times \mathrm{Tr}[P.P]$$

c->d: 16

c->s: 14

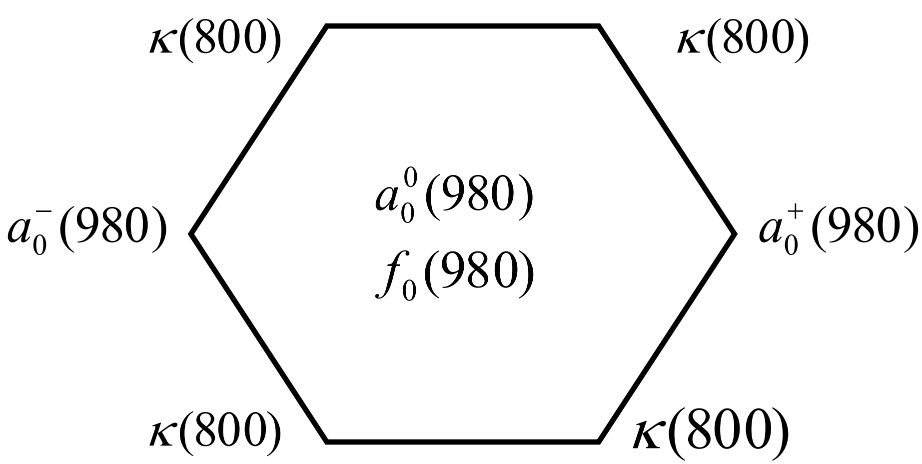
Scalar Mesons: Two nonets

$q\bar{q}$



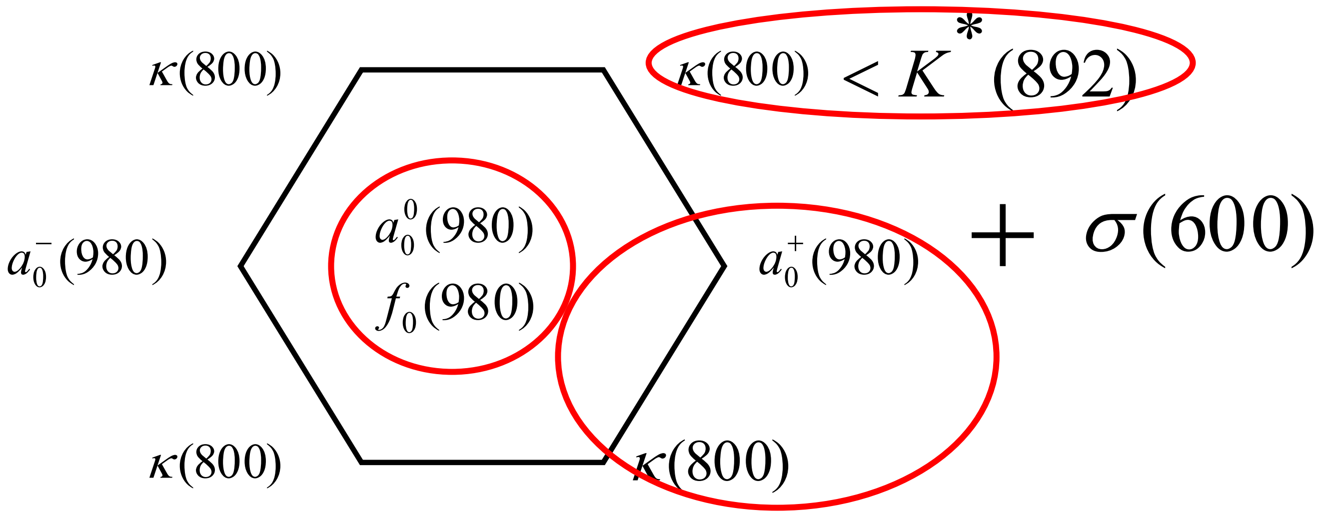
$+ \quad f_0(1370)$
$f_0(1710)$

$q\bar{q}/q^2\bar{q}^2$



$+ \quad \sigma(600)$

标量粒子: 四夸克vs分子态



如何区分两、四夸克态？

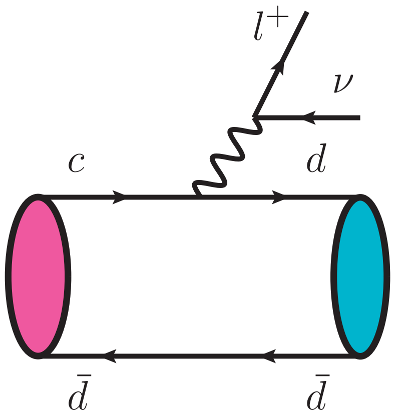
Scalar Mesons: Two nonets

$$|f_0(600)\rangle = \frac{1}{\sqrt{2}}(|\bar{u}u\rangle + |\bar{d}d\rangle) \equiv |\bar{n}n\rangle,$$

$$|f_0(980)\rangle = |\bar{s}s\rangle, \qquad |a_0^0(980)\rangle = \frac{1}{\sqrt{2}}(|\bar{u}u\rangle - |\bar{d}d\rangle),$$

$$|a_0^-(980)\rangle = |\bar{u}d\rangle, \qquad |a_0^+(980)\rangle = |\bar{d}u\rangle.$$

$$|f_0\rangle = |\bar{s}s\rangle\cos\theta + |\bar{n}n\rangle\sin\theta,$$
$$|\sigma\rangle = -|\bar{s}s\rangle\sin\theta + |\bar{n}n\rangle\cos\theta.$$



Lu, WW, PRD82, 034016 (201

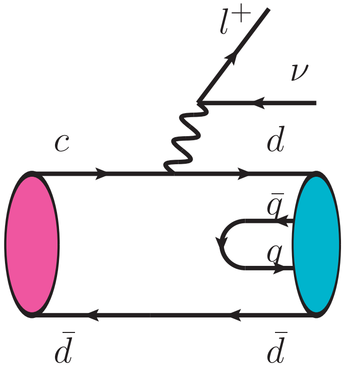
$$\hat{\mathcal{A}} \equiv \mathcal{A}(D^+ \to a_0^0 l^+\nu).$$

$$\mathcal{A}(D^+ \to f_0 l^+\nu) = -\sin\theta\hat{\mathcal{A}},$$
$$\mathcal{A}(D^+ \to \sigma l^+\nu) = -\cos\theta\hat{\mathcal{A}},$$

$$\mathcal{B}(D^+ \to a_0^0 l^+\nu) = \mathcal{B}(D^+ \to f_0 l^+\nu) + \mathcal{B}(D^+ \to \sigma l^+\nu).$$

Scalar Mesons: Two nonets

$$
\begin{aligned}
|\sigma\rangle &= \bar{u}u\bar{d}d, \quad |f_0\rangle = |\bar{n}n\bar{s}s\rangle, \\
|a_0^0\rangle &= \frac{1}{\sqrt{2}}(\bar{u}u - \bar{d}d)\bar{s}s, \\
|a_0^+\rangle &= |\bar{d}u\bar{s}s\rangle, \quad |a_0^-\rangle = |\bar{u}d\bar{s}s\rangle. \\
|\kappa^+\rangle &= |\bar{s}u\bar{d}d\rangle, \quad |\kappa^0\rangle = |\bar{s}d\bar{u}u\rangle, \\
|\bar{\kappa}^0\rangle &= |\bar{d}s\bar{u}u\rangle, \quad |\kappa^-\rangle = |\bar{u}s\bar{d}d\rangle.
\end{aligned}
$$



$$\hat{\mathcal{A}} \equiv \mathcal{A}(D^+ \to a_0^0 l^+ \nu).$$

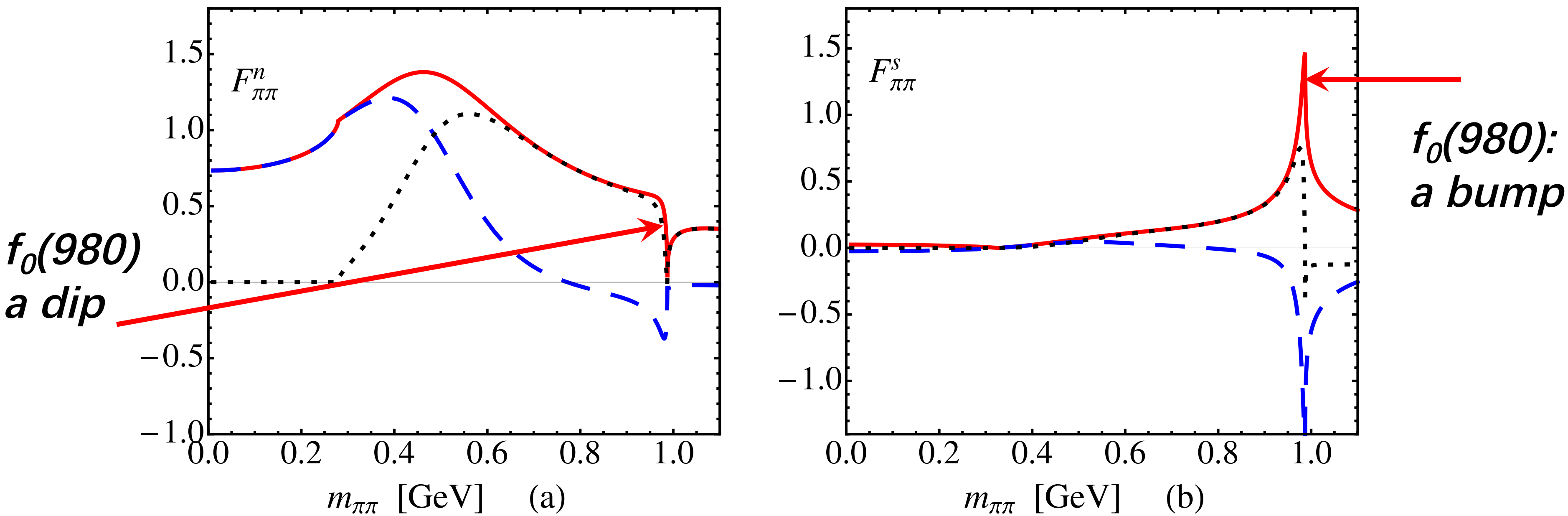
$$
\begin{aligned}
|f_0\rangle &= |\bar{n}n\bar{s}s\rangle \cos\phi + |\bar{u}u\bar{d}d\rangle \sin\phi, \\
|\sigma\rangle &= -|\bar{n}n\bar{s}s\rangle \sin\phi + |\bar{u}u\bar{d}d\rangle \cos\phi,
\end{aligned}
$$

$$
\begin{aligned}
\mathcal{A}(D^+ \to f_0 l^+ \nu) &= -(\cos\phi + \sqrt{2}\sin\phi)\hat{\mathcal{A}}, \\
\mathcal{A}(D^+ \to \sigma l^+ \nu) &= (\sin\phi - \sqrt{2}\cos\phi)\hat{\mathcal{A}},
\end{aligned}
$$

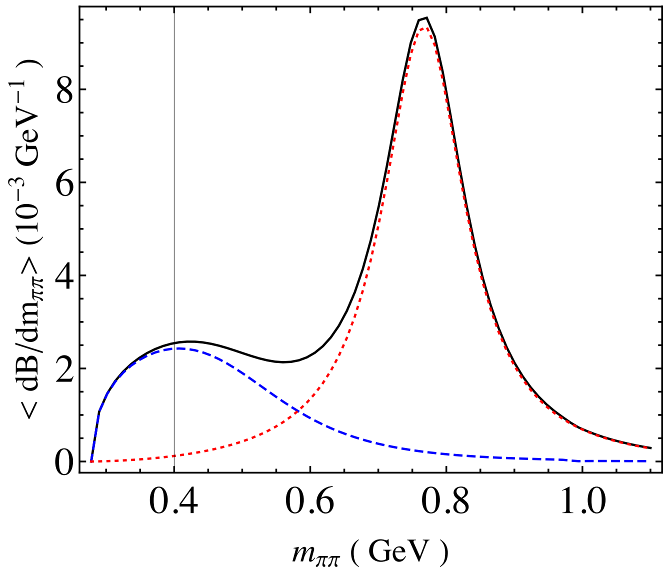
$$\mathcal{B}(D^+ \to a_0^0 l^+ \nu) = \frac{1}{3}[\mathcal{B}(D^+ \to f_0 l^+ \nu) + \mathcal{B}(D^+ \to \sigma l^+ \nu)].$$

$$R = \frac{\mathcal{B}(D^+ \to f_0 l^+ \nu) + \mathcal{B}(D^+ \to \sigma l^+ \nu)}{\mathcal{B}(D^+ \to a_0^0 l^+ \nu)}. = \begin{cases} 1 & \text{two quark} \\ 3 & \text{tetra-quark} \end{cases}.$$

分子态：Scalar form factors in χPT



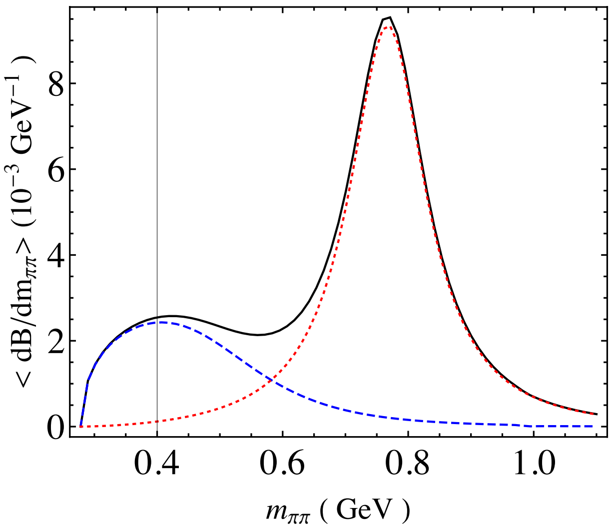
分子态： $D \rightarrow \pi^+\pi^- e\nu$



Red: P-wave
Blue： S-wave
Black: Total

Y.J. Shi, WW, S. Zhao 1701.07571

如何区分标量粒子态：D→π⁺π⁻eν



分子态模型：

Red: P-wave Blue： S-wave Black: Total

The S-wave branching fraction for $2m_\pi < m_{\pi\pi} < 1.0$ GeV is given as

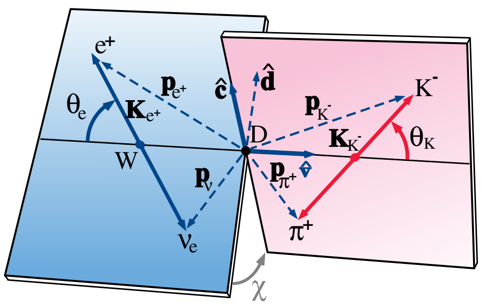
$$\mathcal{B}(D^- \to (\pi^+\pi^-)_S e^-\bar{\nu}) = (6.99 \pm 2.46) \times 10^{-4},$$
$$\mathcal{B}(D^- \to (\pi^+\pi^-)_S \mu^-\bar{\nu}) = (7.20 \pm 2.52) \times 10^{-4}.$$

Y.J. Shi, WW, S. Zhao 1701.07571

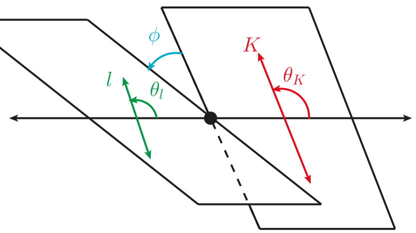
$$R = \frac{\mathcal{B}(D^+ \to f_0 l^+\nu) + \mathcal{B}(D^+ \to \sigma l^+\nu)}{\mathcal{B}(D^+ \to a_0^0 l^+\nu)}. = \begin{cases} 1 & \text{two quark} \\ 3 & \text{tetra-quark} \end{cases}.$$

Lu, WW, PRD82, 034016 (2010)

角分布与散射相移



$$d^5\Gamma = \frac{G_F^2||V_{cs}||^2}{(4\pi)^6 m_D^3} X\beta \mathcal{I}(m^2, q^2, \theta_K, \theta_e, \chi) \times dm^2 dq^2 d\cos(\theta_K) d\cos(\theta_e) d\chi.$$

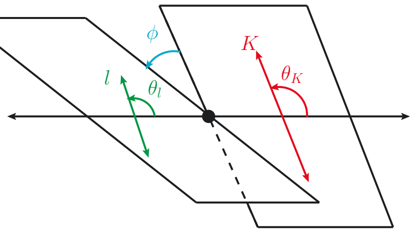


$$\begin{aligned}\frac{d^5\Gamma}{dm_{K\pi}^2 dq^2 d\cos\theta_K d\cos\theta_l d\phi} = \frac{3}{8}\Big[& I_1(q^2, m_{K\pi}^2, \theta_K) \\ & + I_2(q^2, m_{K\pi}^2, \theta_K)\cos(2\theta_l) \\ & + I_3(q^2, m_{K\pi}^2, \theta_K)\sin^2\theta_l\cos(2\phi) \\ & + I_4(q^2, m_{K\pi}^2, \theta_K)\sin(2\theta_l)\cos\phi \\ & + I_5(q^2, m_{K\pi}^2, \theta_K)\sin(\theta_l)\cos\phi \\ & + I_6(q^2, m_{K\pi}^2, \theta_K)\cos\theta_l \\ & + I_7(q^2, m_{K\pi}^2, \theta_K)\sin(\theta_l)\sin\phi \\ & + I_8(q^2, m_{K\pi}^2, \theta_K)\sin(2\theta_l)\sin\phi \\ & + I_9(q^2, m_{K\pi}^2, \theta_K)\sin^2\theta_l\sin(2\phi)\Big],\end{aligned}$$

C. L. Y. Lee, M. Lu, and M. B. Wise, Phys. Rev. D **46**, 5040 (1992).

Meissner, WW, JHEP 1401 (2014) 107

角分布与散射相移



$$\frac{d^3\Gamma}{dq^2 dm_{K\pi}^2 d\cos\theta_K} = \frac{1}{8}\Big\{(4+2\hat{m}_l^2)|A_0^0|^2 + 6\hat{m}_l^2|A_t^0|^2 + \sqrt{3}(8+4\hat{m}_l^2)\cos\theta_K \mathrm{Re}[A_0^0 A_0^{1*}] + 12\sqrt{3}\hat{m}_l^2\cos\theta_K \mathrm{Re}[A_t^0 A_t^{1*}] + (12+6\hat{m}_l^2)|A_0^1|^2\cos^2\theta_K + 18\hat{m}_l^2\cos^2\theta_K|A_t^1|^2 + (6+3\hat{m}_l^2)\sin^2\theta_K(|A_\perp^1|^2 + |A_{||}^1|^2)\Big\}\,. \tag{4.23}$$

$$A_{FB}^K \equiv \left[\int_0^1 - \int_{-1}^0\right] d\cos\theta_K \frac{d^3\Gamma}{dq^2 dm_{K\pi}^2 d\cos\theta_K} = \frac{\sqrt{3}}{2}(2+\hat{m}_l^2)\mathrm{Re}[A_0^0 A_0^{1*}] + \frac{3\sqrt{3}}{2}\hat{m}_l^2 \mathrm{Re}[A_t^0 A_t^{1*}]\,.$$

角分布与散射相移

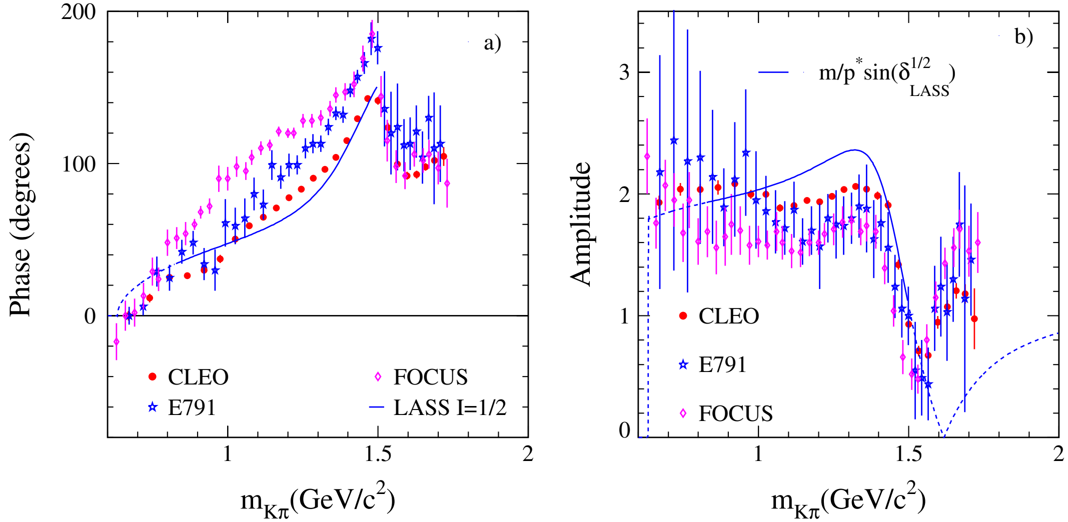
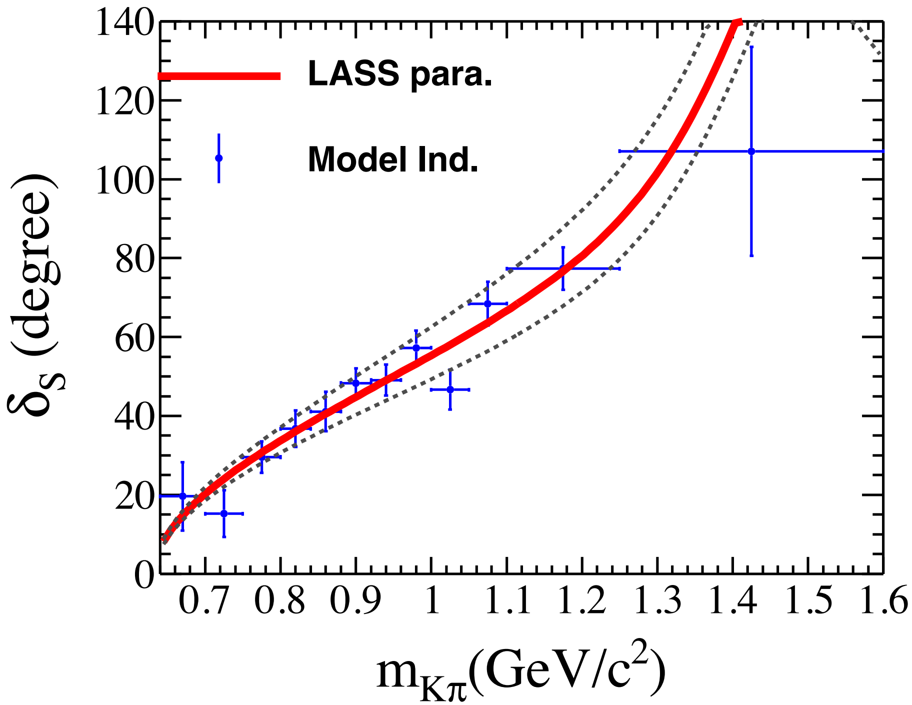


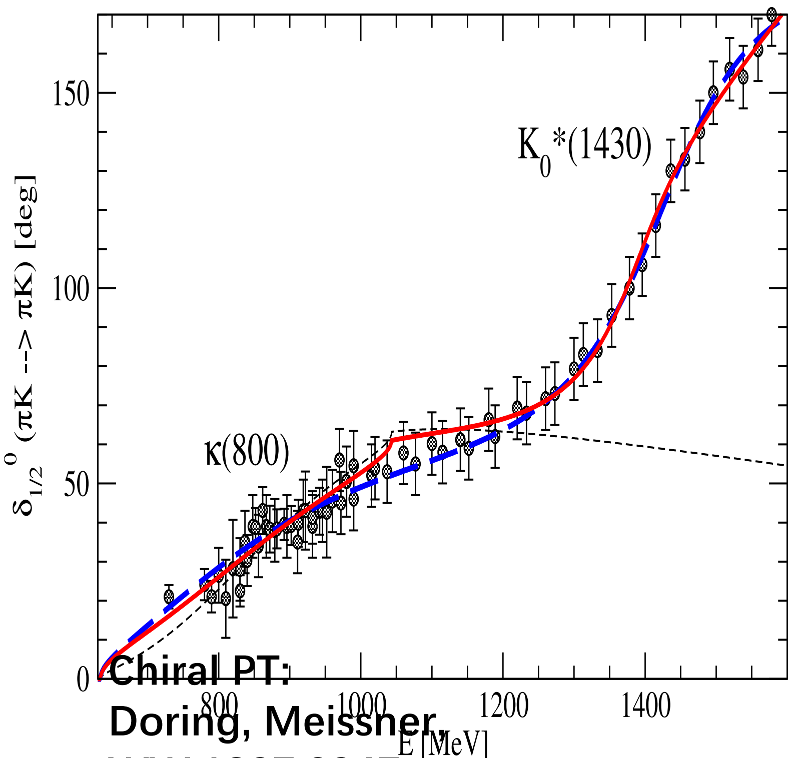
FIG. 2 (color online). (a) Comparison between the S-wave phase measured in various experiments analyzing the $D^+ \to K^- \pi^+ \pi^+$ channel (E791 [6], FOCUS [7,8], and CLEO [9]) and a fit to LASS data (continuous line). The dashed line corresponds to the extrapolation of the fitted curve. Phase measurements from D^+ decays are shifted to be equal to zero at $m_{K\pi} = 0.67\ \text{GeV}/c^2$. (b) The S-wave amplitude magnitude measured in various experiments is compared with the elastic expression. Normalization is arbitrary between the various distributions.

BaBar:Phys.Rev. D83 (2011) 072001

角分布与散射相移



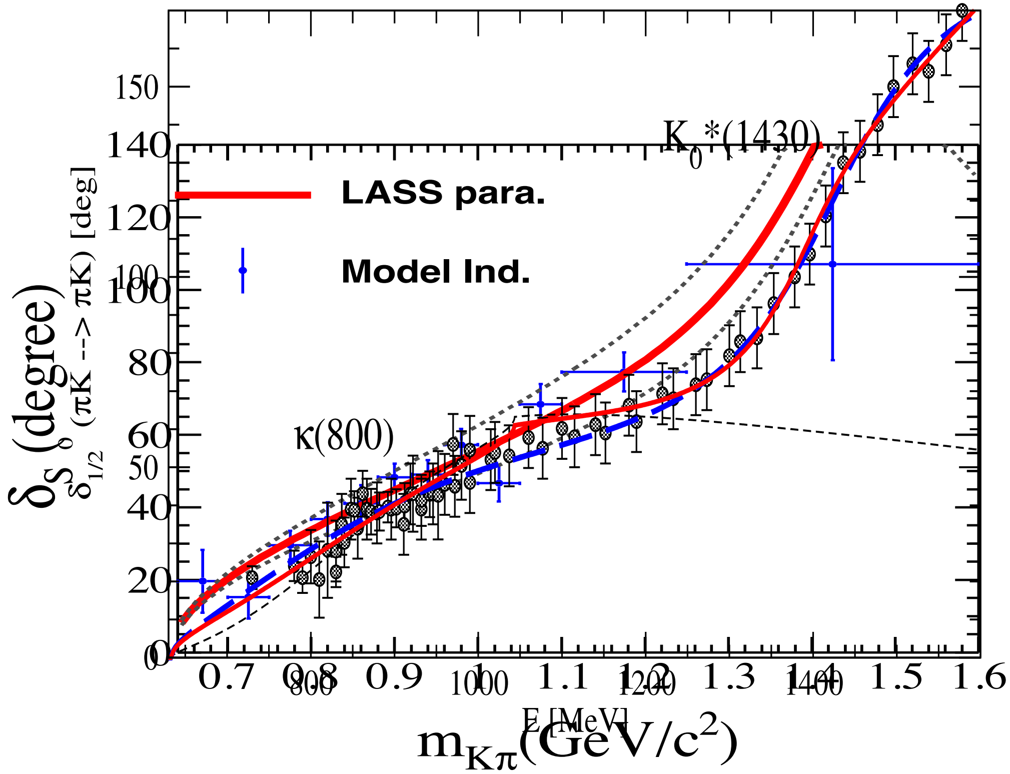
BESIII, 1512.08627



Chiral PT:
Doring, Meissner, WW,1307.0947

Points with error bars by BESIII
the solid line corresponds to LASS parameterization

角分布与散射相移



BESIII, 1512.08627

Points with error bars by BESIII
the solid line corresponds to LASS parameterization

Chiral PT:
Doring, Meissner, WW,1307.0947

上海交通大学
SHANGHAI JIAO TONG UNIVERSITY

50:1

50:1

Expected data set increase and ~ increase in inst. Luminosity

$$\frac{50}{1} = \frac{\text{LHCb Upgrade}}{\text{LHCb today}} = \frac{\text{Belle II}}{\text{BaBar} + \text{Belle}} = \frac{\text{BaBar} + \text{Belle}}{\text{CLEO}} = \frac{?}{\text{BESIII}}$$

the energy increase from **7/8 TeV** to **13 TeV** at the **LHC**

Summary

- 双粲重子
  - 双粲重子弱衰变：续集
- $D \to P_1 P_2 l\nu$
  - 检验标量粒子内部结构
  - 测量散射相移
  - 手征有效理论+QCD微扰理论

谢谢大家！

请批评指正！