Classifying the hidden-charm pentaquarks via a flavor mixing scheme

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K. Chen and B. Wang, Phys.Rev.D 109 (2024) 11, 114028

K. Chen, Z. Y. Lin,and S. L. Zhu, Phys.Rev.D 106 (2022) 11, 116017

Outline

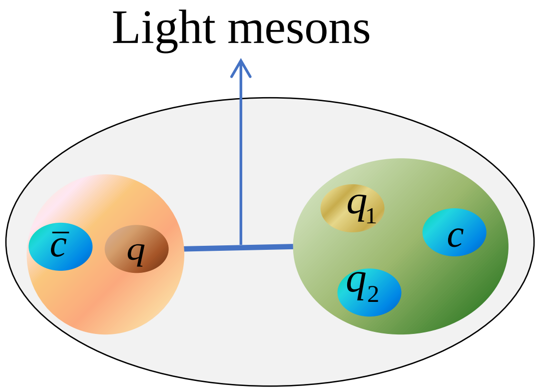
- Motivation
- Flavor mixing scheme
- Numerical results and discussion
- Summary

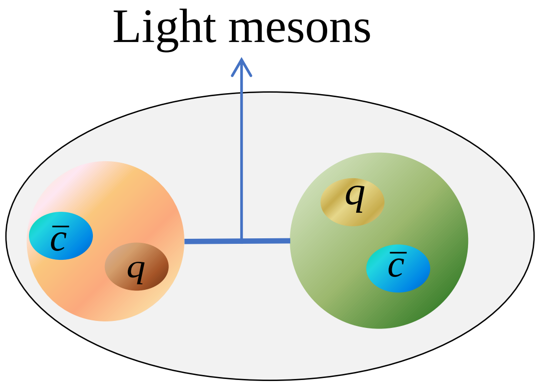
Motivation

	Mass (Expt.)	BE (Expt.)
$\bar{T}^{f}_{cc}(3875)^{+}$	3874.8	-1.0
$P^{N}_{\psi}(4312)^{+}$	$4311.9 \pm 0.9^{+6.8}_{-0.6}$	$-8.9^{+6.8}_{-0.9}$
$P^{N}_{\psi}(4440)^{+}$	$4440.3 \pm 1.3^{+4.1}_{-4.7}$	$-21.8^{+4.3}_{-4.9}$
$P^{N}_{\psi}(4457)^{+}$	$4457.3 \pm 0.6^{+4.1}_{-1.7}$	$-4.8^{+4.1}_{-1.8}$
$P^{\Lambda}_{\psi s}(4338)^{0}$	$4338.2 \pm 0.7 \pm 0.4$	-0.0
$P^{\Lambda}_{\psi s}(4459)^{0}$	$4458.8 \pm 2.9^{+4.7}_{-1.1}$	$-19.7^{+5.5}_{-3.1}$

Nature Commun. 13 (2022) 1, 3351
Nature Phys. 18 (2022) 7, 751-754
Phys.Rev.Lett.115,072001(2015)
Phys. Rev. Lett. 122(22), 222001 (2019)
Sci. Bull. 66, 1278–1287 (2021)
Phys.Rev.Lett. 131 (2023) 3, 031901

Motivation





Light quarks: provide the attractive force

Omit the exchange of $\bar{c}c$ heavy meson

Light quark component ⟹ Interaction

Binding energy

Motivation

Meson	$\|I m_I\rangle$	$\phi^M_{I m_I}$	Meson	$\|I m_I\rangle$	$\phi^M_{I m_I}$
$\bar{D}^{(*)0}$	$\|\frac{1}{2}\frac{1}{2}\rangle$	$u\bar{c}$	$\bar{D}^{(*)-}$	$\|\frac{1}{2}-\frac{1}{2}\rangle$	$d\bar{c}$
$\bar{D}_s^{(*)-}$	$\|00\rangle$	$s\bar{c}$			
Baryon	$\|I m_I\rangle$	$\phi^B_{I m_I}$	**Baryon**	$\|I m_I\rangle$	$\phi^B_{I m_I}$
Λ_c^+	$\|00\rangle$	$\frac{1}{\sqrt{2}}(du-ud)c$	$\Sigma_c^{(*)++}$	$\|11\rangle$	uuc
$\Sigma_c^{(*)+}$	$\|10\rangle$	$\frac{1}{\sqrt{2}}(ud+du)c$	$\Sigma_c^{(*)0}$	$\|1-1\rangle$	ddc
Ξ_c^+	$\|\frac{1}{2}\frac{1}{2}\rangle$	$\frac{1}{\sqrt{2}}(us-su)c$	Ξ_c^0	$\|\frac{1}{2}-\frac{1}{2}\rangle$	$\frac{1}{\sqrt{2}}(ds-sd)c$
$\Xi_c^{\prime(*)+}$	$\|\frac{1}{2}\frac{1}{2}\rangle$	$\frac{1}{\sqrt{2}}(us+su)c$	$\Xi_c^{\prime(*)0}$	$\|\frac{1}{2}-\frac{1}{2}\rangle$	$\frac{1}{\sqrt{2}}(ds+sd)c$
$\Xi_{cc}^{(*)++}$	$\|\frac{1}{2}\frac{1}{2}\rangle$	ucc	$\Xi_{cc}^{(*)+}$	$\|\frac{1}{2}-\frac{1}{2}\rangle$	dcc
$\Omega_{cc}^{(*)+}$	$\|00\rangle$	scc			

Hadron	$\|S m_S\rangle$	$\phi^M_{S m_S}$	Hadron	$\|S m_S\rangle$	$\phi^M_{S m_S}$
				$\|11\rangle$	$\uparrow\uparrow$
$\bar{D}/\bar{D}_s$	$\|00\rangle$	$\frac{1}{\sqrt{2}}(\uparrow\downarrow-\downarrow\uparrow)$	$\bar{D}^*/\bar{D}_s^*$	$\|10\rangle$	$\frac{1}{\sqrt{2}}(\uparrow\downarrow+\downarrow\uparrow)$
				$\|1-1\rangle$	$\downarrow\downarrow$
Hadron	$\|S m_S\rangle$	$\phi^B_{S m_S}$	**Hadron**	$\|S m_S\rangle$	$\phi^B_{S m_S}$
Λ_c/Ξ_c	$\|\frac{1}{2}\frac{1}{2}\rangle$	$\frac{1}{\sqrt{2}}(\uparrow\downarrow-\downarrow\uparrow)\uparrow$			
	$\|\frac{1}{2}-\frac{1}{2}\rangle$	$\frac{1}{\sqrt{2}}(\uparrow\downarrow-\downarrow\uparrow)\downarrow$		$\|\frac{3}{2}\frac{3}{2}\rangle$	$\uparrow\uparrow\uparrow$
Σ_c/Ξ_c'	$\|\frac{1}{2}\frac{1}{2}\rangle$	$-\frac{1}{\sqrt{6}}(\uparrow\downarrow+\downarrow\uparrow)\uparrow+\sqrt{\frac{2}{3}}\uparrow\uparrow\downarrow$	Σ_c^*/Ξ_c^*	$\|\frac{3}{2}\frac{1}{2}\rangle$	$\sqrt{\frac{1}{3}}(\uparrow\uparrow\downarrow+\uparrow\downarrow\uparrow+\downarrow\uparrow\uparrow)$
	$\|\frac{1}{2}-\frac{1}{2}\rangle$	$\frac{1}{\sqrt{6}}(\uparrow\downarrow+\downarrow\uparrow)\downarrow-\sqrt{\frac{2}{3}}\downarrow\downarrow\uparrow$	$/\Xi_{cc}^*/\Omega_{cc}^*$	$\|\frac{3}{2}-\frac{1}{2}\rangle$	$\sqrt{\frac{1}{3}}(\uparrow\downarrow\downarrow+\downarrow\uparrow\downarrow+\downarrow\downarrow\uparrow)$
Ξ_{cc}/Ω_{cc}	$\|\frac{1}{2}\frac{1}{2}\rangle$	$-\frac{1}{\sqrt{6}}\uparrow(\uparrow\downarrow+\downarrow\uparrow)+\sqrt{\frac{2}{3}}\downarrow\uparrow\uparrow$		$\|\frac{3}{2}-\frac{3}{2}\rangle$	$\downarrow\downarrow\downarrow$
	$\|\frac{1}{2}-\frac{1}{2}\rangle$	$\frac{1}{\sqrt{6}}\downarrow(\uparrow\downarrow+\downarrow\uparrow)-\sqrt{\frac{2}{3}}\uparrow\downarrow\downarrow$			

$$
\begin{aligned}
|[H_1H_2]^I_J\rangle = & \sum_{m_{I_1} m_{I_2}} C^{I,I_z}_{I_1,m_{I_1};I_2,m_{I_2}}\phi^{H_1}_{I_1,m_{I_1}}\phi^{H_2}_{I_2,m_{I_2}} \\
& \otimes \sum_{m_{S_1},m_{S_2}} C^{J,J_z}_{S_1,m_{S_1},S_2,m_{S_2}}\phi^{H_1}_{S_1,m_{S_1}}\phi^{H_2}_{S_2,m_{S_2}}
\end{aligned}
$$

Motivation

$$\mathcal{V} = \tilde{g}_s \boldsymbol{\lambda}_1 \cdot \boldsymbol{\lambda}_2 + \tilde{g}_a \boldsymbol{\lambda}_1 \cdot \boldsymbol{\lambda}_2 \boldsymbol{\sigma}_1 \cdot \boldsymbol{\sigma}_2$$

L. Meng, B. Wang, G. J. Wang, and S.L.Zhu, *Phys.Rept.* 1019 (2023) 1-149

S-wave interaction

Scalar mesons

Axial-vector mesons

$$\frac{g^2}{m_{\rm ex}^2 + q^2} \approx \frac{g^2}{m_{\rm ex}^2} \equiv \tilde{g}_s \text{ or } \tilde{g}_a$$

$$\text{Scenario 1}: P_\psi^N(4440)|\Sigma_c\bar{D}^*; \frac{1}{2}^-\rangle, P_\psi^N(4457)|\Sigma_c\bar{D}^*; \frac{3}{2}^-\rangle$$

$$\text{Scenario 2}: P_\psi^N(4457)|\Sigma_c\bar{D}^*; \frac{1}{2}^-\rangle, P_\psi^N(4440)|\Sigma_c\bar{D}^*; \frac{3}{2}^-\rangle$$

$$\mathrm{Re}\left|\left|\mathbb{I} - \mathbb{V}_{1/2}^{P_\psi^N}\mathbb{G}_{1/2}^{P_\psi^N}\right|\right| = 0$$

$$\mathrm{Im}\left|\left|\mathbb{I} - \mathbb{V}_{1/2}^{P_\psi^N}\mathbb{G}_{1/2}^{P_\psi^N}\right|\right| = 0$$

$$\mathrm{Re}\left|\left|\mathbb{I} - \mathbb{V}_{3/2}^{P_\psi^N}\mathbb{G}_{3/2}^{P_\psi^N}\right|\right| = 0$$

$$\mathrm{Im}\left|\left|\mathbb{I} - \mathbb{V}_{3/2}^{P_\psi^N}\mathbb{G}_{3/2}^{P_\psi^N}\right|\right| = 0$$

$$\text{Scenario 1}: \underline{\tilde{g}_s = 8.28\,\mathrm{GeV}^{-2}}, \tilde{g}_a = -1.46\,\mathrm{GeV}^{-2},$$

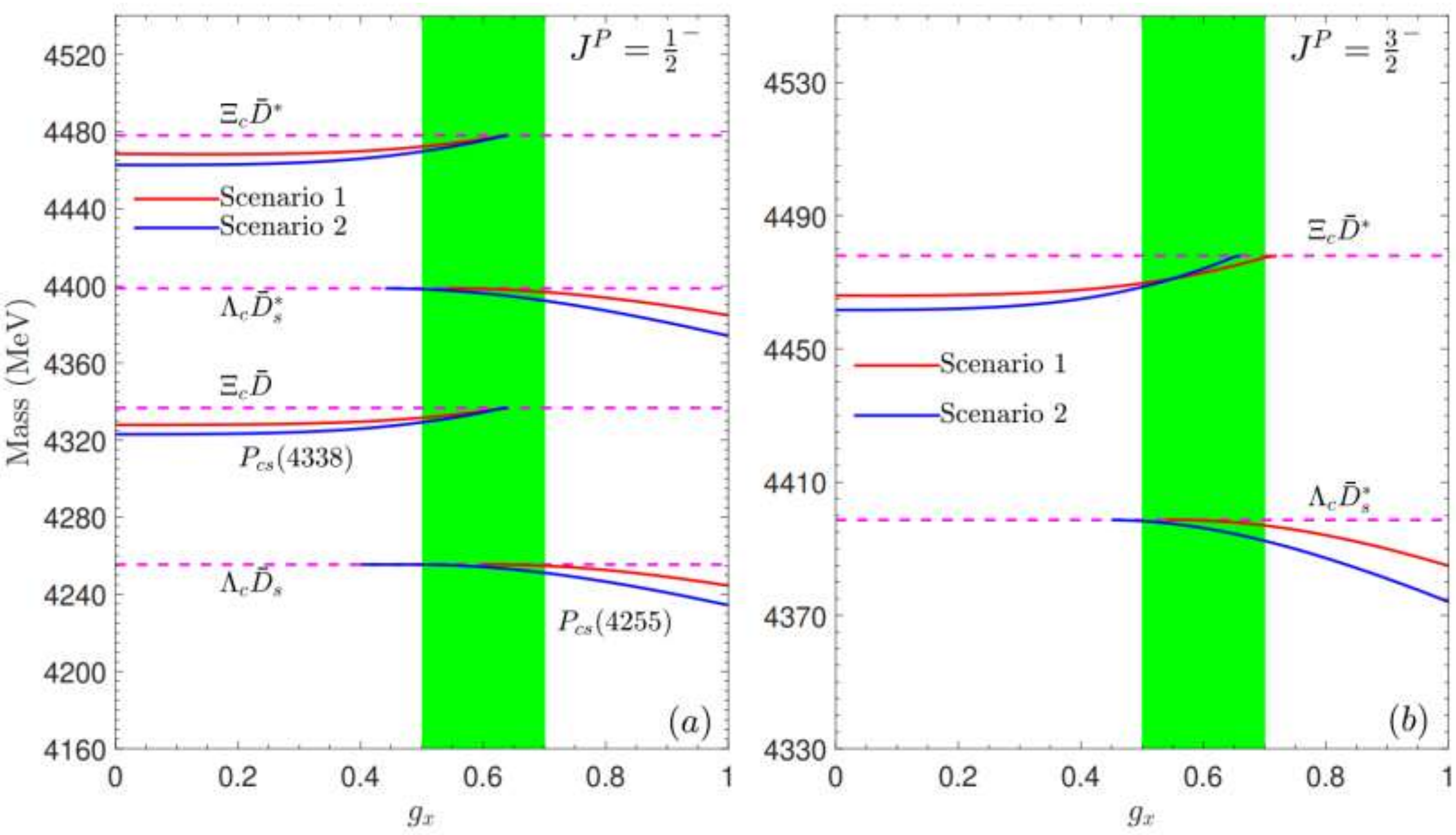
$$\text{Scenario 2}: \underline{\tilde{g}_s = 9.12\,\mathrm{GeV}^{-2}}, \tilde{g}_a = 1.25\,\mathrm{GeV}^{-2}.$$

Flavor dominant

K.Chen, Z-Y Lin, and S-L Zhu, Phys.Rev.D 106 (2022) 11, 116017

K.Chen and B. Wang, Phys.Rev.D 109 (2024) 11, 114028

Motivation



K.Chen and B. Wang, Phys.Rev.D 109 (2024) 11, 114028
K. Chen, R. Chen, L Meng, B. Wang, S-L Zhu, Eur.Phys.J.C 82 (2022) 7, 581

$$\mathbb{V} = \begin{pmatrix} V^{\Lambda_c\bar{D}_s\to\Lambda_c\bar{D}_s} & V^{\Lambda_c\bar{D}_s\to\Xi_c\bar{D}} \\ V^{\Xi_c\bar{D}\to\Lambda_c\bar{D}_s} & V^{\Xi_c\bar{D}\to\Xi_c\bar{D}} \end{pmatrix} = \begin{pmatrix} -\frac{4}{3}\tilde{g}_s & -2\sqrt{2}\tilde{g}_s g_x \\ -2\sqrt{2}\tilde{g}_s g_x & -\frac{10}{3}\tilde{g}_s \end{pmatrix}.$$

SU(3) breaking effect

$$\boldsymbol{\lambda}_1 \cdot \boldsymbol{\lambda}_2 = \sum_{i=1}^{8} \lambda_1^i \lambda_2^i$$

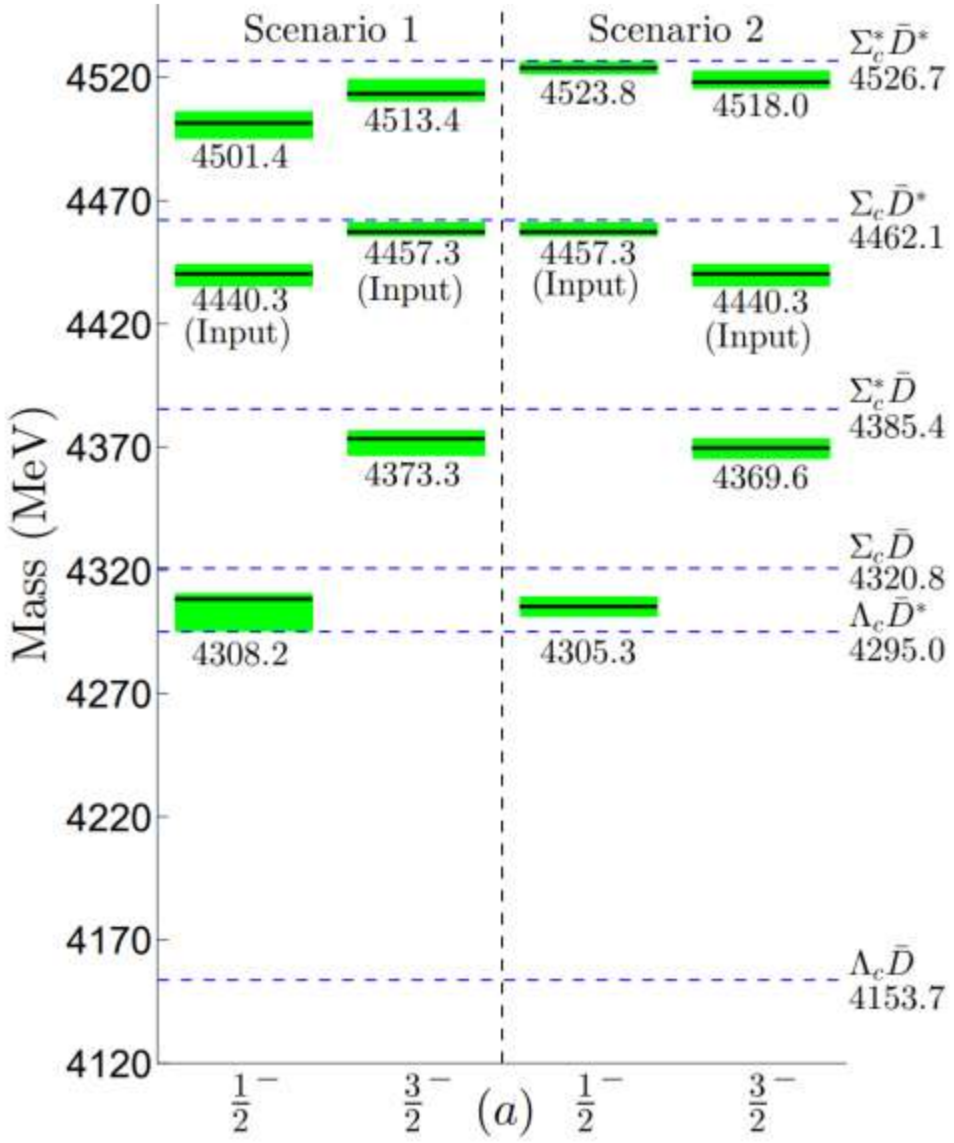
$$g_x = \frac{1}{m_s^2} / \frac{1}{m_{\text{nons}}^2} = \frac{m_{\text{nons}}^2}{m_s^2}$$

$$\tilde{g}_s \to \tilde{g}_s g_x \quad g_x \in [0,1]$$

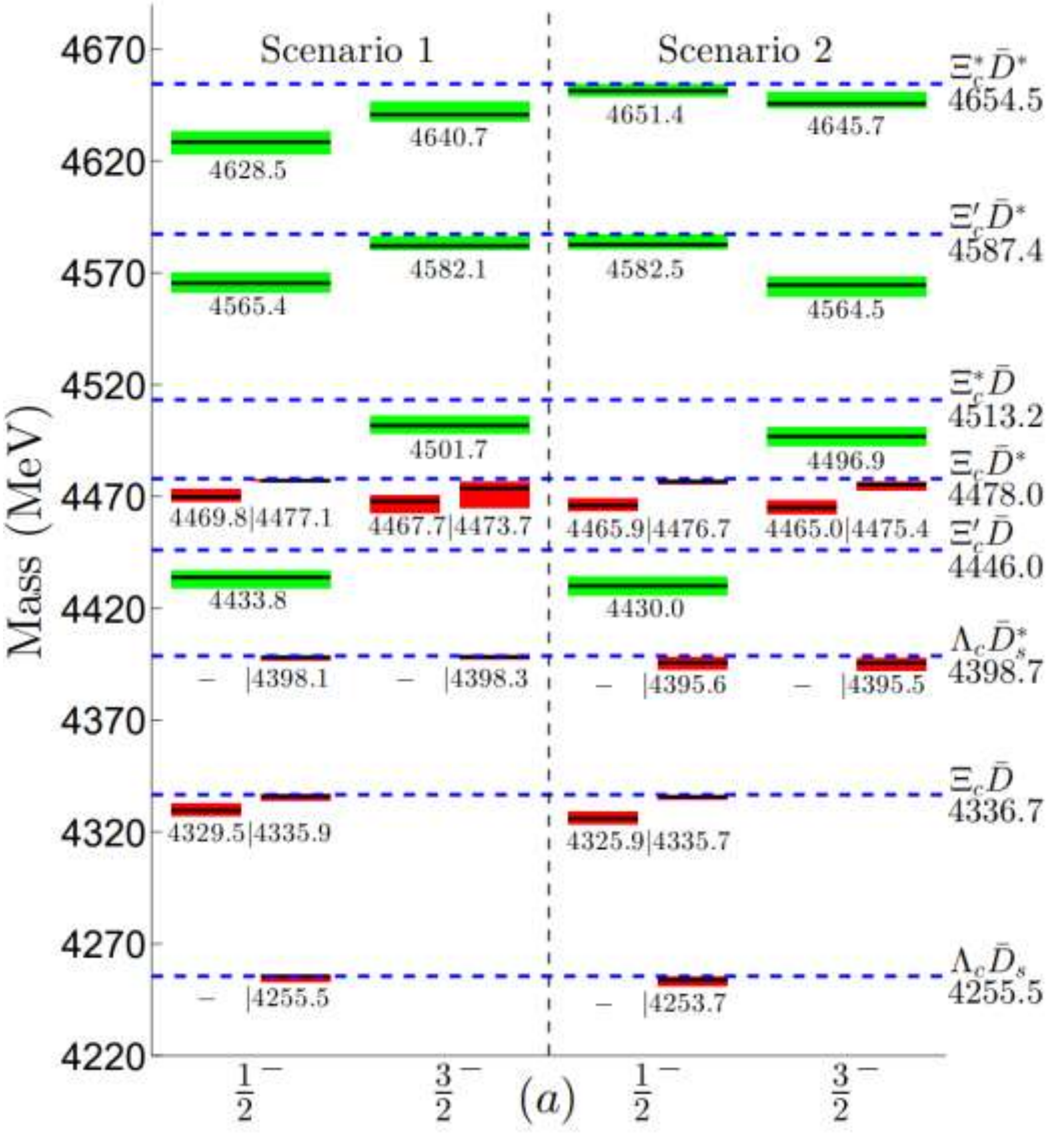
for i =4, 5, 6, 7

Suppression factor g_x for the exchange of strange light meson

Motivation



Scenario 1
Scenario 2
Mass (MeV)
$\Sigma_c^*\bar{D}^*$ 4526.7
$\Sigma_c\bar{D}^*$ 4462.1
$\Sigma_c^*\bar{D}$ 4385.4
$\Sigma_c\bar{D}$ 4320.8
$\Lambda_c\bar{D}^*$ 4295.0
$\Lambda_c\bar{D}$ 4153.7
4501.4
4513.4
4523.8
4518.0
4440.3 (Input)
4457.3 (Input)
4457.3 (Input)
4440.3 (Input)
4373.3
4369.6
4308.2
4305.3
$\frac{1}{2}^-$ $\frac{3}{2}^-$ (a) $\frac{1}{2}^-$ $\frac{3}{2}^-$



Scenario 1
Scenario 2
Mass (MeV)
$\Xi_c^*\bar{D}^*$ 4654.5
$\Xi_c'\bar{D}^*$ 4587.4
$\Xi_c^*\bar{D}$ 4513.2
$\Xi_c\bar{D}^*$ 4478.0
$\Xi_c'\bar{D}$ 4446.0
$\Lambda_c\bar{D}_s^*$ 4398.7
$\Xi_c\bar{D}$ 4336.7
$\Lambda_c\bar{D}_s$ 4255.5
4628.5
4640.7
4651.4
4645.7
4565.4
4582.1
4582.5
4564.5
4501.7
4496.9
4469.8|4477.1
4467.7|4473.7
4465.9|4476.7
4465.0|4475.4
4433.8
4430.0
– |4398.1
– |4398.3
– |4395.6
– |4395.5
4329.5|4335.9
4325.9|4335.7
– |4255.5
– |4253.7
$\frac{1}{2}^-$ $\frac{3}{2}^-$ (a) $\frac{1}{2}^-$ $\frac{3}{2}^-$

Flavor mixing scheme

$Y = B + S$

$\|R, Y, I\rangle$	Wave function
$\|\mathbf{1}, 0, 0\rangle$	$\sqrt{\frac{1}{3}}\|\Lambda_c \bar{D}_s^{(*)}\rangle + \sqrt{\frac{2}{3}}\|\Xi_c \bar{D}^{(*)}\rangle$
$\|\mathbf{8}, 1, \frac{1}{2}\rangle$	$\|\Lambda_c \bar{D}^{(*)}\rangle$
$\|\mathbf{8}, 0, 0\rangle$	$\sqrt{\frac{2}{3}}\|\Lambda_c \bar{D}_s^{(*)}\rangle - \sqrt{\frac{1}{3}}\|\Xi_c \bar{D}^{(*)}\rangle$
$\|\mathbf{8}, 0, 1\rangle$	$\|\Xi_c \bar{D}^{(*)}\rangle$
$\|\mathbf{8}, -1, \frac{1}{2}\rangle$	$\|\Xi_c \bar{D}_s^{(*)}\rangle$
$\|\mathbf{8}', 1, \frac{1}{2}\rangle$	$-\|\Sigma_c^{(*)} \bar{D}^{(*)}\rangle$
$\|\mathbf{8}', 0, 0\rangle$	$\|\Xi_c'^{(*)} \bar{D}^{(*)}\rangle$
$\|\mathbf{8}', 0, 1\rangle$	$\sqrt{\frac{2}{3}}\|\Sigma_c^{(*)} \bar{D}_s^{(*)}\rangle - \sqrt{\frac{1}{3}}\|\Xi_c'^{(*)} \bar{D}^{(*)}\rangle$
$\|\mathbf{8}', -1, \frac{1}{2}\rangle$	$\sqrt{\frac{1}{3}}\|\Xi_c'^{(*)} \bar{D}_s^{(*)}\rangle - \sqrt{\frac{2}{3}}\|\Omega_c^{(*)} \bar{D}^{(*)}\rangle$
$\|\mathbf{10}, 1, \frac{3}{2}\rangle$	$\|\Sigma_c^{(*)} \bar{D}^{(*)}\rangle$
$\|\mathbf{10}, 0, 1\rangle$	$\sqrt{\frac{1}{3}}\|\Sigma_c^{(*)} \bar{D}_s^{(*)}\rangle + \sqrt{\frac{2}{3}}\|\Xi_c'^{(*)} \bar{D}^{(*)}\rangle$
$\|\mathbf{10}, -1, \frac{1}{2}\rangle$	$\sqrt{\frac{1}{3}}\|\Omega_c^{(*)} \bar{D}^{(*)}\rangle + \sqrt{\frac{2}{3}}\|\Xi_c'^{(*)} \bar{D}_s^{(*)}\rangle$
$\|\mathbf{10}, -2, 0\rangle$	$\|\Omega_c^{(*)} \bar{D}_s^{(*)}\rangle$

Open charm molecular tetraquark $\mathbf{3} \otimes \mathbf{3} = \bar{\mathbf{3}} \oplus \mathbf{6}$

Hidden charm molecular pentaquark $\mathbf{3} \otimes \mathbf{3} = \bar{\mathbf{3}} \oplus \mathbf{6}$ $\Rightarrow$

$$\begin{aligned} \bar{\mathbf{3}} \otimes \mathbf{3}' &= \mathbf{1} \oplus \mathbf{8} \\ \mathbf{6} \otimes \mathbf{3}' &= \mathbf{8}' \oplus \mathbf{10} \end{aligned}$$

$(\bar{c}q)(\bar{c}q)$	$\langle \boldsymbol{\lambda}_1 \cdot \boldsymbol{\lambda}_2 \rangle$	Exp
$\|\bar{\mathbf{3}}\rangle$	$-\frac{8}{3}$	$T_{cc}(3874)$
$\|\mathbf{6}\rangle$	$\frac{4}{3}$	–
$(cqq)(\bar{c}q)$	$\langle \boldsymbol{\lambda}_1 \cdot \boldsymbol{\lambda}_2 \rangle$	
$\|\mathbf{1}\rangle$	$-\frac{16}{3}$	$P_{cs}(4338)$, $P_{cs}(4459)$
$\|\mathbf{8}\rangle$	$\frac{2}{3}$	–
$\|\mathbf{8}'\rangle$	$-\frac{10}{3}$	$P_c(4312)$,$P_c(4440)$,$P_c(4457)$
$\|\mathbf{10}\rangle$	$\frac{8}{3}$	–

$I = 1$ P_{cs} states and double-strange hidden-charm pentaquark

[1] Saturation model
[2] Potential quark model
[3] HQS
[4-5] Local hidden gauge formalism
[6] QCD sum rule

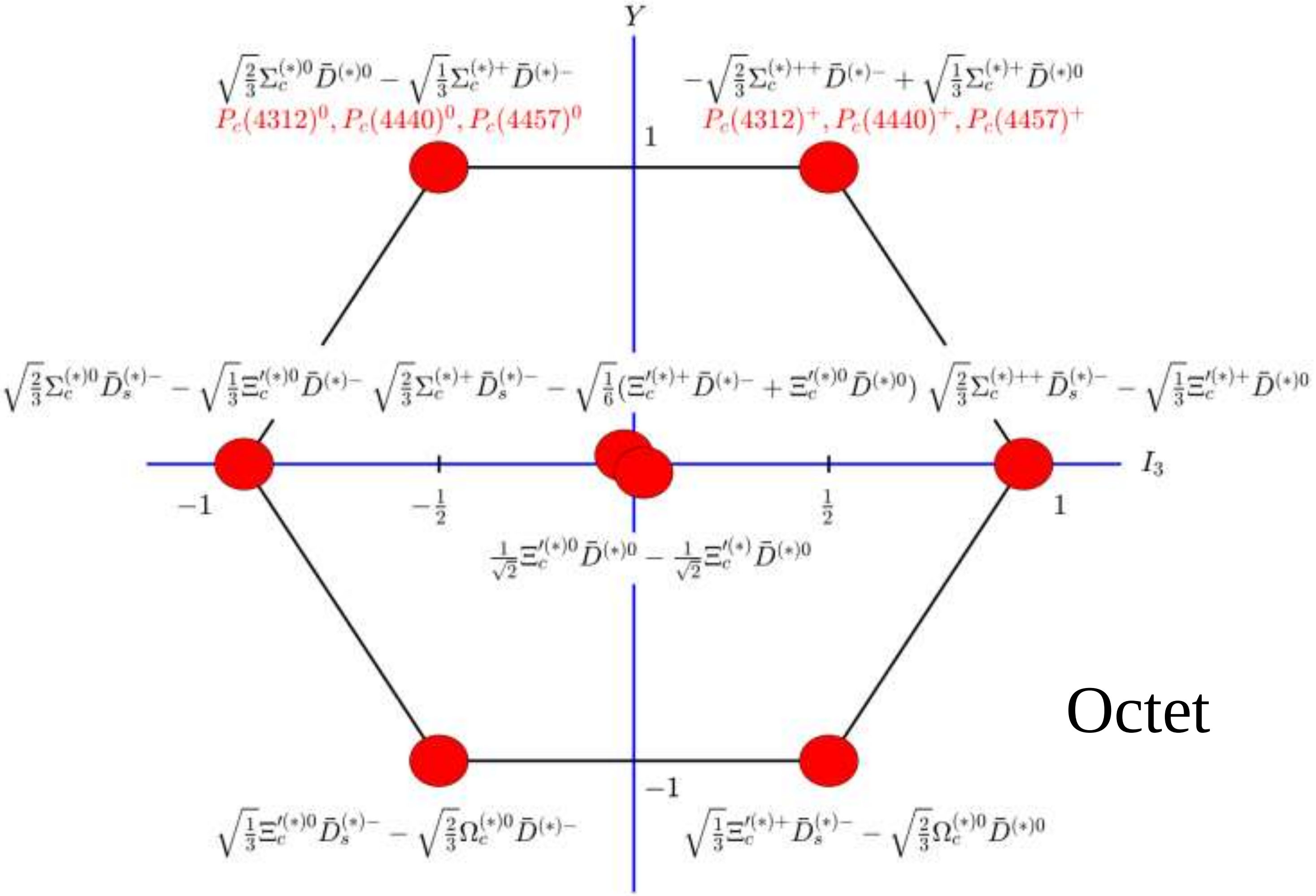
[1].Z. Y. Yang, F. Z. Peng, M. J. Yan, M. Sánchez Sánchez and M. Pavon Valderrama, Phys. Rev. D 111, no.1, 014012 (2025)
[2].P. G. Ortega, D. R. Entem and F. Fernandez, Phys. Lett. B 838, 137747 (2023).
[3].F. Z. Peng, M. Z. Liu, Y. W. Pan, M. Sánchez Sánchez and M. Pavon Valderrama, Nucl. Phys. B 983, 115936 (2022).
[4].L. Roca, J. Song and E. Oset, Phys. Rev. D 109, no.9, 094005 (2024).
[5].E. E. Garcia-Gonzales, V. K. Magas and A. Ramos, arXiv:2605.21205 [hep-ph]
[6].Z. G. Wang, arXiv:2606.28095.

Triple-strange hidden-charm pentaquark

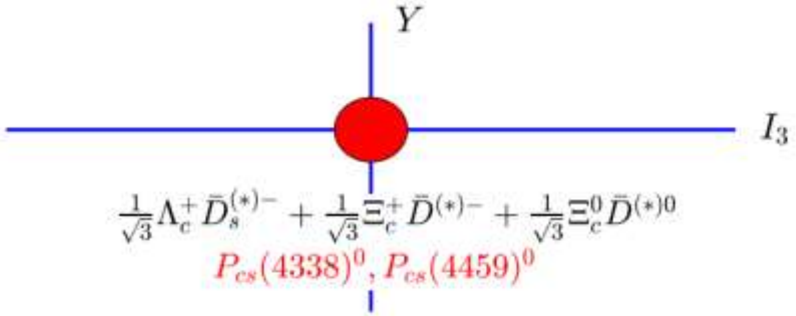
[7] OBE model
[8] Saturation model
[9] Off-shell coupled-channel approach
[10] Potential quark model
[11] Local hidden gauge approach

[7].F. L. Wang, X. D. Yang, R. Chen and X. Liu, Phys. Rev. D 103, no.5, 054025 (2021)
[8].Z. Y. Yang, F. Z. Peng, M. J. Yan, M. Sánchez Sánchez and M. Pavon Valderrama, Phys. Rev. D 111, no.1, 014012 (2025)
[9].S. Clymton, H. C. Kim and T. Mart, Phys. Rev. D 112, no.9, 094024 (2025).
[10].Q. Meng, E. Hiyama, K. U. Can, P. Gubler, M. Oka, A. Hosaka and H. Zong, Phys. Lett. B 798, 135028 (2019)
[11].L. Roca, J. Song and E. Oset, Phys. Rev. D 109, no.9, 094005 (2024)

Flavor mixing scheme



Octet



Singlet

Flavor mixing scheme

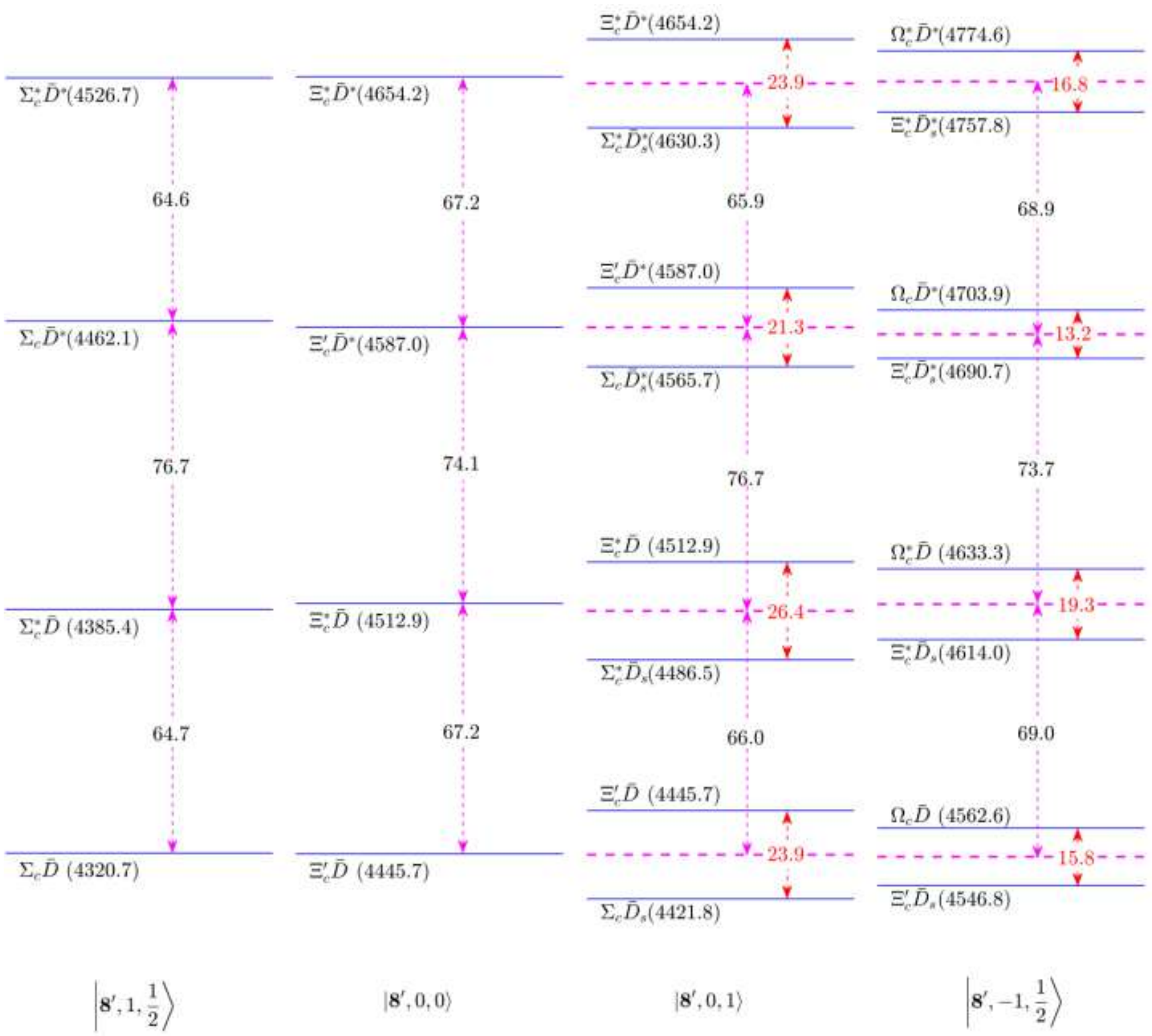
Coupled channel effect

$$\boldsymbol{\lambda}_1 \cdot \boldsymbol{\lambda}_2 = \sum_{i=1}^{8} \lambda_1^i \lambda_2^i$$

Dominant

$$\boldsymbol{\lambda}_1 \cdot \boldsymbol{\lambda}_2 (\boldsymbol{\sigma}_1 \cdot \boldsymbol{\sigma}_2) = \sum_{i=1}^{8} \lambda_1^i \lambda_2^i (\boldsymbol{\sigma}_1 \cdot \boldsymbol{\sigma}_2)$$

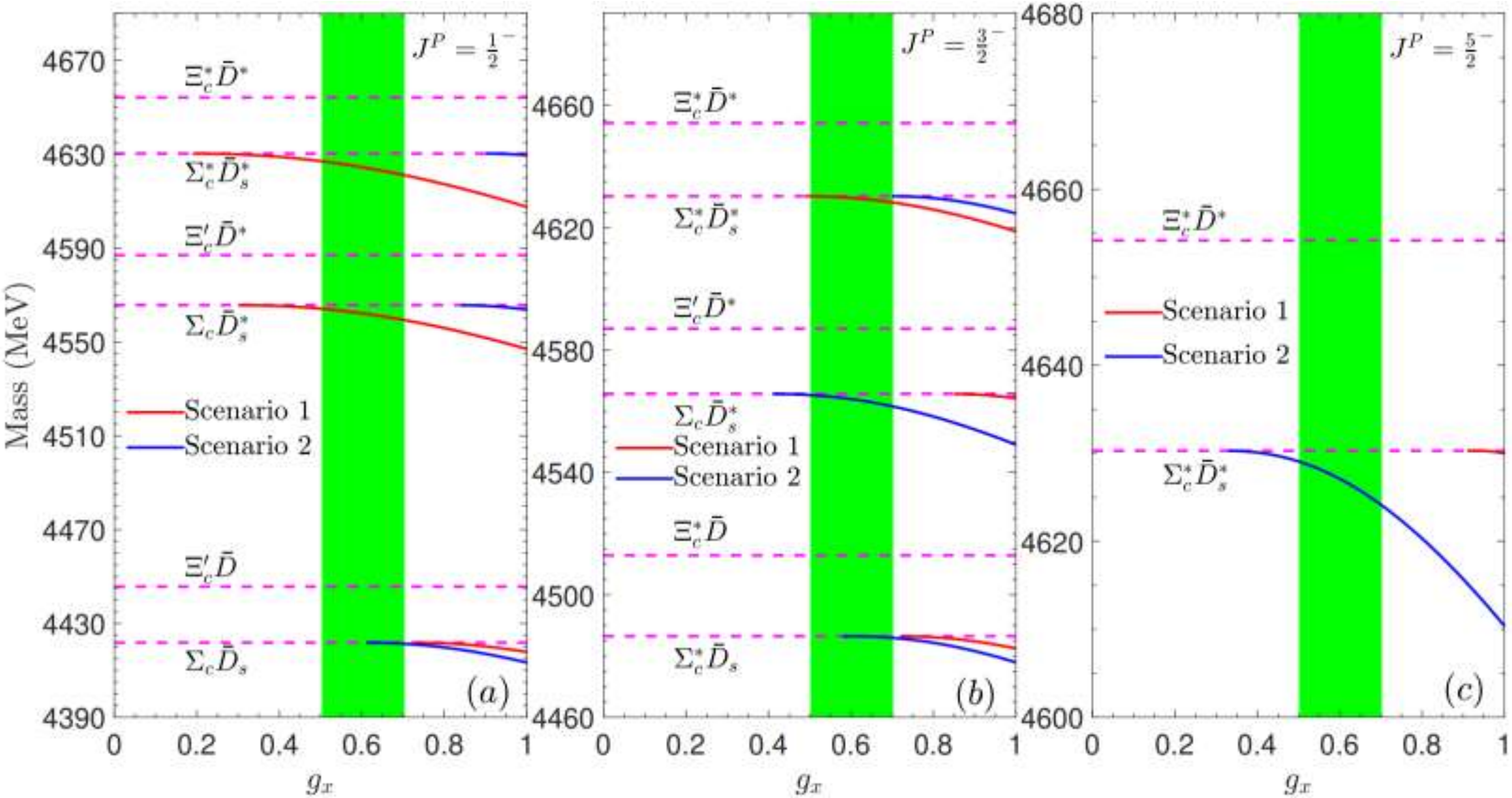
Insignificant



Result and discussion

	$[\langle\mathcal{O}^{\mathrm{f}}\rangle, \langle\mathcal{O}^{\mathrm{fs}}\rangle]$	$\langle\mathcal{O}^{\mathrm{f}}_{\mathrm{Eig}}\rangle$	$\langle\mathcal{O}^{\mathrm{fs}}_{\mathrm{Eig}}\rangle$
$(\lvert\Sigma_c\bar{D}_s\rangle^{1}_{\frac{1}{2}},\ \lvert\Xi_c'\bar{D}\rangle^{1}_{\frac{1}{2}})$	$\begin{pmatrix} [-\frac{4}{3},0] & [2\sqrt{2}g_x,0] \\ & [\frac{2}{3},0] \end{pmatrix}$	$\begin{pmatrix} -\frac{10}{3} \\ \frac{8}{3} \end{pmatrix}$	$\begin{pmatrix} 0 \\ 0 \end{pmatrix}$

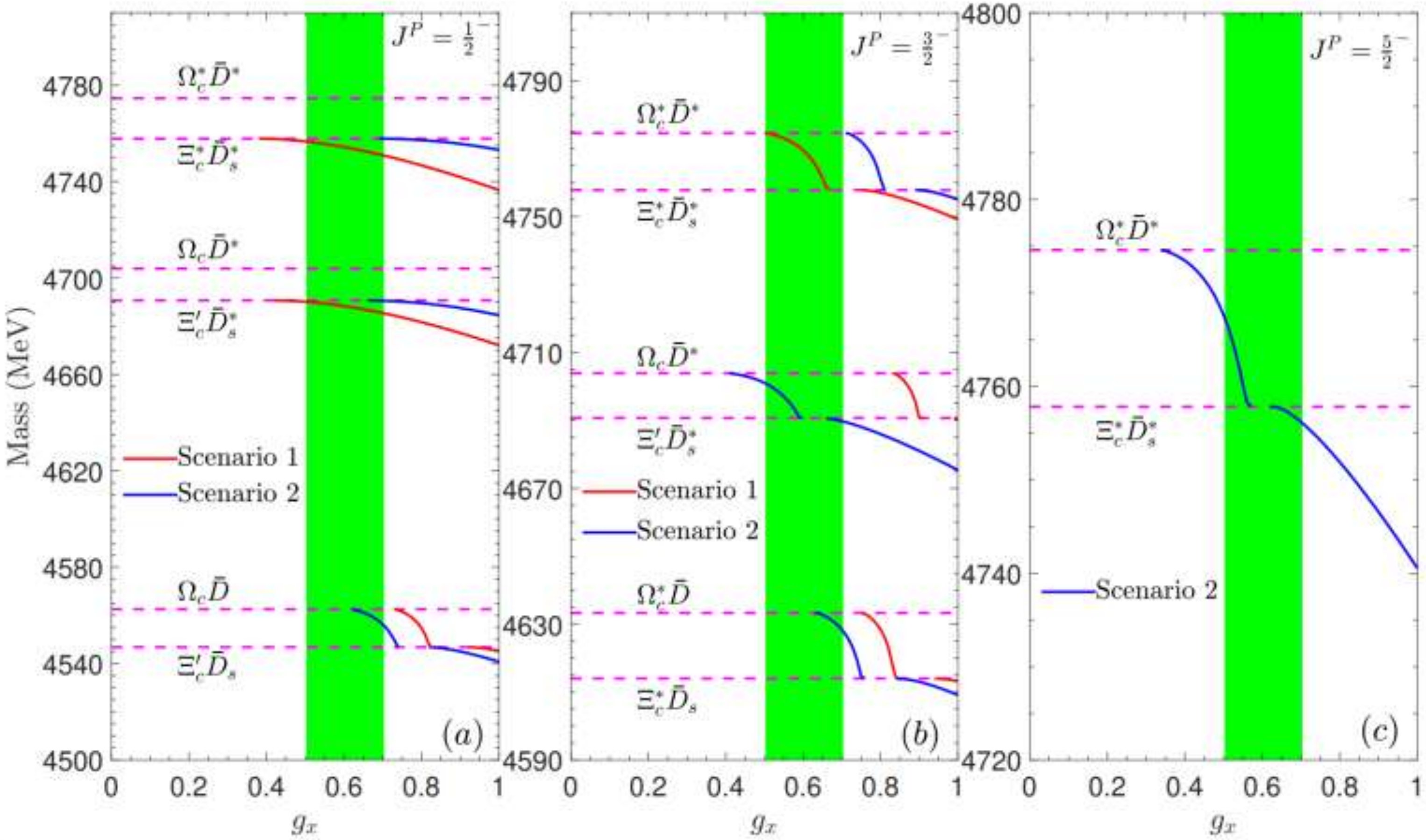
$$|\mathbf{8}', 0, 1\rangle$$



Result and discussion

	$[\langle\mathcal{O}^{\rm f}\rangle, \langle\mathcal{O}^{\rm fs}\rangle]$	$\langle\mathcal{O}^{\rm f}_{\rm Eig}\rangle$	$\langle\mathcal{O}^{\rm fs}_{\rm Eig}\rangle$
$(\lvert\Xi_c'\bar{D}_s\rangle^{\frac{1}{2}}_{\frac{1}{2}},\ \lvert\Omega_c\bar{D}\rangle^{\frac{1}{2}}_{\frac{1}{2}})$	$\begin{pmatrix} [\frac{2}{3},0] & [2\sqrt{2}g_x,0] \\ & [-\frac{4}{3},0] \end{pmatrix}$	$\begin{pmatrix} -\frac{10}{3} \\ \frac{8}{3} \end{pmatrix}$	$\begin{pmatrix} 0 \\ 0 \end{pmatrix}$

$$\left|\mathbf{8}', -1, \frac{1}{2}\right\rangle$$



Result and discussion

Components	$I(J^P)$	Scenario 1	Scenario 2	Components	$I(J^P)$	Scenario 1	Scenario 2
$\Sigma_c\bar{D}_s-\Xi_c'\bar{D}$	$1(\frac{1}{2}^-)$	-	$4421.8^{+*}_{-0.4}$	$\Xi_c'\bar{D}_s-\Omega_c\bar{D}$	$\frac{1}{2}(\frac{1}{2}^-)$	-	$4562.6^{+*}_{-6.3}$
$\Sigma_c\bar{D}_s^*-\Xi_c'\bar{D}^*$	$1(\frac{1}{2}^-)$	$4562.2^{+1.8}_{-2.8}$	-	$\Xi_c'\bar{D}_s^*-\Omega_c\bar{D}^*$	$\frac{1}{2}(\frac{1}{2}^-)$	$4688.4^{+1.8}_{-3.0}$	-
$\Sigma_c^*\bar{D}_s^*-\Xi_c^*\bar{D}^*$	$1(\frac{1}{2}^-)$	$4624.5^{+2.6}_{-3.3}$	-	$\Xi_c'\bar{D}_s^*-\Omega_c^*\bar{D}^*$	$\frac{1}{2}(\frac{1}{2}^-)$	$4754.3^{+2.4}_{-3.4}$	-
$\Sigma_c^*\bar{D}_s-\Xi_c^*\bar{D}_s$	$1(\frac{3}{2}^-)$	-	$4486.5^{+*}_{-0.5}$	$\Xi_c^*\bar{D}_s-\Omega_c^*\bar{D}$	$\frac{1}{2}(\frac{3}{2}^-)$	-	$4633.3^{+*}_{-4.9}$
$\Sigma_c\bar{D}_s^*-\Xi_c'\bar{D}^*$	$1(\frac{3}{2}^-)$	-	$4564.0^{+1.3}_{-2.4}$	$\Xi_c'\bar{D}_s^*-\Omega_c\bar{D}^*$	$\frac{1}{2}(\frac{3}{2}^-)$	-	$4690.7^{+10.3}_{-0.9}$
$\Sigma_c^*\bar{D}_s^*-\Xi_c^*\bar{D}^*$	$1(\frac{3}{2}^-)$	$4629.7^{+0.6}_{-1.4}$	-	$\Xi_c^*\bar{D}_s^*-\Omega_c^*\bar{D}^*$	$\frac{1}{2}(\frac{3}{2}^-)$	$4769.5^{+5.1}_{-11.7}$	-
$\Sigma_c^*\bar{D}_s^*-\Xi_c^*\bar{D}^*$	$1(\frac{5}{2}^-)$	-	$4627.1^{+2.0}_{-2.9}$	$\Xi_c^*\bar{D}_s^*-\Omega_c^*\bar{D}^*$	$\frac{1}{2}(\frac{5}{2}^-)$	-	$4757.8^{+9.8}_{-1.6}$
Components	$I(J^P)$	Scenario 1	Scenario 2	Components	$I(J^P)$	Scenario 1	Scenario 2
$\Sigma_c\bar{D}$	$\frac{1}{2}(\frac{1}{2}^-)$	$4308.2^{+2.2}_{-13.2}$	$4305.3^{+3.9}_{-4.2}$	$\Xi_c'\bar{D}$	$0(\frac{1}{2}^-)$	$4433.8^{+3.4}_{-4.9}$	$4430.0^{+4.1}_{-4.3}$
$\Sigma_c\bar{D}^*$	$\frac{1}{2}(\frac{1}{2}^-)$	$^{\dagger}4440.3^{+4.0}_{-5.0}$	$^{\dagger}4457.3^{+4.0}_{-1.8}$	$\Xi_c'\bar{D}^*$	$0(\frac{1}{2}^-)$	$4565.4^{+4.6}_{-4.5}$	$4582.5^{+4.6}_{-2.2}$
$\Sigma_c^*\bar{D}^*$	$\frac{1}{2}(\frac{1}{2}^-)$	$4501.4^{+5.0}_{-6.2}$	$4523.8^{+2.8}_{-2.4}$	$\Xi_c^*\bar{D}^*$	$0(\frac{1}{2}^-)$	$4628.5^{+4.8}_{-5.5}$	$4651.4^{+3.2}_{-2.6}$
$\Sigma_c^*\bar{D}$	$\frac{1}{2}(\frac{3}{2}^-)$	$4373.3^{+3.4}_{-6.8}$	$4369.6^{+4.0}_{-4.3}$	$\Xi_c^*\bar{D}$	$0(\frac{3}{2}^-)$	$4501.7^{+4.5}_{-3.5}$	$4496.9^{+4.2}_{-4.2}$
$\Sigma_c\bar{D}^*$	$\frac{1}{2}(\frac{3}{2}^-)$	$^{\dagger}4457.3^{+4.0}_{-1.8}$	$^{\dagger}4440.3^{+4.0}_{-5.0}$	$\Xi_c'\bar{D}^*$	$0(\frac{3}{2}^-)$	$4582.1^{+4.2}_{-2.0}$	$4564.5^{+4.1}_{-5.1}$
$\Sigma_c^*\bar{D}^*$	$\frac{1}{2}(\frac{3}{2}^-)$	$4513.4^{+5.7}_{-3.2}$	$4518.0^{+4.9}_{-2.5}$	$\Xi_c^*\bar{D}^*$	$0(\frac{3}{2}^-)$	$4640.7^{+5.8}_{-3.1}$	$4645.7^{+5.0}_{-2.3}$
$\Sigma_c^*\bar{D}^*$	$\frac{1}{2}(\frac{5}{2}^-)$	$4523.8^{+2.0}_{-1.2}$	$4501.6^{+3.4}_{-2.2}$	$\Xi_c^*\bar{D}^*$	$0(\frac{5}{2}^-)$	$4651.2^{+2.0}_{-1.3}$	$4628.2^{+3.3}_{-2.2}$

Summary

1. We suggest a possible way to classify the hidden charm pentaquark states.
2. The $\mathbf{1}$ and $\mathbf{8}'$ channels can form bound states, while the $\mathbf{8}$ and $\mathbf{10}$ channels can not form bound states.
3. The flavor mixing significantly influences the pole positions of the mixed states.

Thanks for your attention!