The X(3872) and X,Y,Z states

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The X(3872) as a D D*bar molecule
Role of charged and neutral channels. Isospin considerations
Some X,Y,Z states as hidden charm vector-vector molecules
Radiative decay of these X,Y,Z states.

Hidden gauge formalism for vector mesons, pseudoscalars and photons

Bando et al. PRL, 112 (85); Phys. Rep. 164, 217 (88)

$$\mathcal{L} = \mathcal{L}^{(2)} + \mathcal{L}_{III} \tag{1}$$

with

$$\mathcal{L}^{(2)} = \frac{1}{4} f^2 \langle D_\mu U D^\mu U^\dagger + \chi U^\dagger + \chi^\dagger U \rangle \tag{2}$$

$$\mathcal{L}_{III} = -\frac{1}{4} \langle V_{\mu\nu} V^{\mu\nu} \rangle + \frac{1}{2} M_V^2 \langle [V_\mu - \frac{i}{g} \Gamma_\mu]^2 \rangle, \tag{3}$$

where $\langle ... \rangle$ represents a trace over $SU(3)$ matrices. The covariant derivative is defined by

$$D_\mu U = \partial_\mu U - ieQA_\mu U + ieUQA_\mu, \tag{4}$$

with $Q = diag(2, -1, -1)/3$, $e = -|e|$ the electron charge, and A_μ the photon field. The chiral matrix U is given by

$$U = e^{i\sqrt{2}\phi/f} \tag{5}$$

$$\phi \equiv \begin{pmatrix} \frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta_8 & \pi^+ & K^+ \\ \pi^- & -\frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta_8 & K^0 \\ K^- & \bar{K}^0 & -\frac{2}{\sqrt{6}}\eta_8 \end{pmatrix}, \quad V_\mu \equiv \begin{pmatrix} \frac{1}{\sqrt{2}}\rho^0 + \frac{1}{\sqrt{2}}\omega & \rho^+ & K^{*+} \\ \rho^- & -\frac{1}{\sqrt{2}}\rho^0 + \frac{1}{\sqrt{2}}\omega & K^{*0} \\ K^{*-} & \bar{K}^{*0} & \phi \end{pmatrix}_\mu . \tag{6}$$

In $\mathcal{L}_{III}$, $V_{\mu\nu}$ is defined as

$$V_{\mu\nu} = \partial_\mu V_\nu - \partial_\nu V_\mu - ig[V_\mu, V_\nu] \tag{9}$$

and

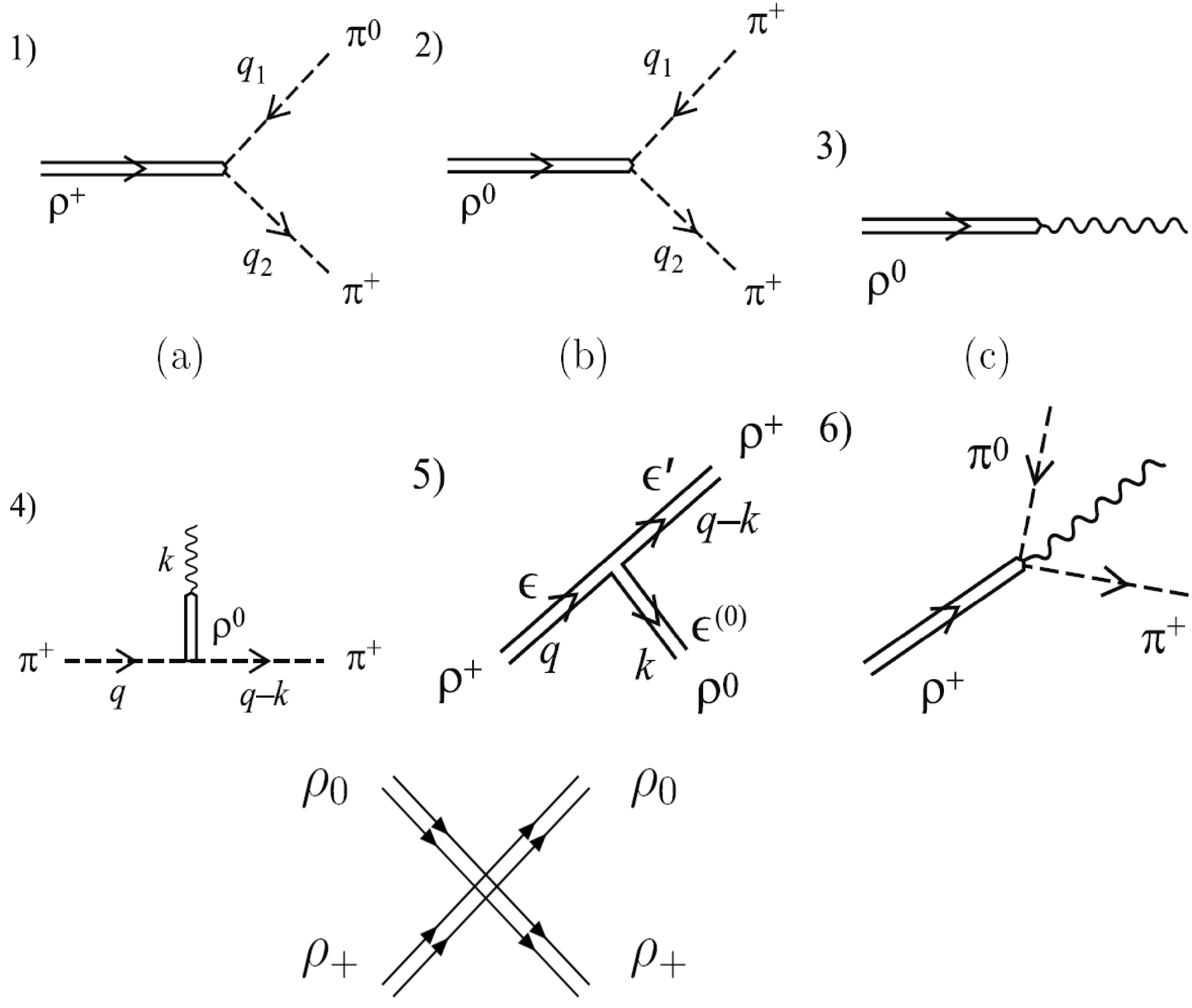
$$\Gamma_\mu = \frac{1}{2}[u^\dagger(\partial_\mu - ieQA_\mu)u + u(\partial_\mu - ieQA_\mu)u^\dagger] \tag{10}$$

with $u^2 = U$. The hidden gauge coupling constant g is related to f and the vector meson mass (M_V) through

$$g = \frac{M_V}{2f}, \tag{11}$$

$$\mathcal{L}_{V\gamma} = -M_V^2 \frac{e}{g} A_\mu \langle V^\mu Q \rangle$$
$$\mathcal{L}_{V\gamma PP} = e\frac{M_V^2}{4gf^2} A_\mu \langle V^\mu (Q\phi^2 + \phi^2 Q - 2\phi Q \phi) \rangle$$
$$\mathcal{L}_{VPP} = -i\frac{M_V^2}{4gf^2} \langle V^\mu [\phi, \partial_\mu \phi] \rangle$$

$$\mathcal{L}_{III}^{(c)} = \frac{g^2}{2} \langle V_\mu V_\nu V^\mu V^\nu - V_\nu V_\mu V^\mu V^\nu \rangle \ , \qquad \mathcal{L}_{III}^{(3V)} = ig \langle (\partial_\mu V_\nu - \partial_\nu V_\mu) V^\mu V^\nu \rangle \ ,$$


1)
π^0
q_1
ρ^+
q_2
π^+
2)
π^+
q_1
ρ^0
q_2
π^+
3)
ρ^0
(a)
(b)
(c)
4)
k
ρ^0
π^+
q
$q-k$
π^+
5)
ρ^+
ϵ'
$q-k$
ϵ
$\epsilon^{(0)}$
ρ^+
q
k
ρ^0
6)
π^0
π^+
ρ^+
ρ_0
ρ_0
ρ_+
ρ_+

The Lagrangians are extended to SU(4), but it is broken because the exchange of heavy vector mesons is much reduced compared to the light ones.

$$\Phi = \begin{pmatrix} \frac{\eta}{\sqrt{3}} + \frac{\pi^0}{\sqrt{2}} + \frac{\eta'}{\sqrt{6}} & \pi^+ & K^+ & \overline{D}^0 \\ \pi^- & \frac{\eta}{\sqrt{3}} - \frac{\pi^0}{\sqrt{2}} + \frac{\eta'}{\sqrt{6}} & K^0 & D^- \\ K^- & \overline{K}^0 & \sqrt{\frac{2}{3}}\eta' - \frac{\eta}{\sqrt{3}} & D_s{}^- \\ D^0 & D^+ & D_s{}^+ & \eta_c \end{pmatrix}$$

$$\mathcal{V}_\mu = \begin{pmatrix} \frac{\rho^0_\mu}{\sqrt{2}} + \frac{\omega_\mu}{\sqrt{2}} & \rho^+_\mu & K^{*+}_\mu & \bar{D}^{*0}_\mu \\ \rho^{*-}_\mu & \frac{-\rho^0_\mu}{\sqrt{2}} + \frac{\omega_\mu}{\sqrt{2}} & K^{*0}_\mu & D^{*-}_\mu \\ K^{*-}_\mu & \bar{K}^{*0}_\mu & \phi_\mu & D^{*-}_{s\mu} \\ D^{*0}_\mu & D^{*+}_\mu & D^{*+}_{s\mu} & J/\psi_\mu \end{pmatrix}.$$

Vector – pseudoscalar interaction

$$\mathcal{M}^C_{ij}(s,t,u) = \frac{-\xi^C_{ij}}{4f^2}(s-u)\epsilon.\epsilon'.$$

This kernel projected over s-wave and used as kernel
In the Bethe Salpeter equation.

Charm	Strangeness	$I^G(J^{PC})$	Channels
1	1	$1(1^+)$	πD^*_s, $D_s\rho$ KD^*, DK^*
		$0(1^+)$	DK^*, KD^*, ηD^*_s $D_s\omega$, $\eta_c D^*_s$, $D_s J/\psi$
	0	$\frac{1}{2}(1^+)$	πD^*, $D\rho$, KD^*_s, D_sK^* ηD^*, $D\omega$, $\eta_c D^*$, DJ/ψ
	-1	$0(1^+)$	DK^*, KD^*
0	1	$\frac{1}{2}(1^+)$	πK^*, $K\rho$, ηK^*, $K\omega$ $\bar{D}D^*_s$, $D_s\bar{D}^*$, KJ/ψ, $\eta_c K^*$
	0	$1^+(1^{+-})$	$\frac{1}{\sqrt{2}}(\bar{K}K^* + c.c.)$, $\pi\omega$, $\eta\rho$ $\frac{1}{\sqrt{2}}(\bar{D}D^* + c.c.)$, $\eta_c\rho$, $\pi J/\psi$
		$1^-(1^{++})$	$\pi\rho$, $\frac{1}{\sqrt{2}}(\bar{K}K^* - c.c.)$, $\frac{1}{\sqrt{2}}(\bar{D}D^* - c.c.)$
		$0^+(1^{++})$	$\frac{1}{\sqrt{2}}(\bar{K}K^* + c.c.)$, $\frac{1}{\sqrt{2}}(\bar{D}D^* + c.c.)$, $\frac{1}{\sqrt{2}}(\bar{D}_sD^*_s - c.c.)$
		$0^-(1^{+-})$	$\pi\rho$, $\eta\omega$, $\frac{1}{\sqrt{2}}(\bar{D}D^* - c.c.)$, $\eta_c\omega$ $\eta J/\psi$, $\frac{1}{\sqrt{2}}(\bar{D}_sD^*_s + c.c.)$, $\frac{1}{\sqrt{2}}(\bar{K}K^* - c.c.)$, $\eta_c J/\psi$

X(3872)

$$\mathcal{M}_{ij}^C(s,t,u) = \frac{-\xi_{ij}^C}{4f^2}(s-u)\epsilon.\epsilon'.$$

Projected over s-wave

$$T = V + VGT$$

$$G_{ii} = \frac{1}{16\pi^2}\left(\alpha_i + Log\frac{m_1^2}{\mu^2} + \frac{m_2^2 - m_1^2 + s}{2s} Log\frac{m_2^2}{m_1^2} + \frac{p}{\sqrt{s}}\left(Log\frac{s - m_2^2 + m_1^2 + 2p\sqrt{s}}{-s + m_2^2 - m_1^2 + 2p\sqrt{s}} + Log\frac{s + m_2^2 - m_1^2 + 2p\sqrt{s}}{-s - m_2^2 + m_1^2 + 2p\sqrt{s}}\right)\right)$$

One searches for poles in the complex plane: they correspond to bound states or resonances.

C	Irrep Mass (MeV)	S	$I^G(J^{PC})$	$RE(\sqrt{s})$ (MeV)	$IM(\sqrt{s})$ (MeV)	Resonance ID
1	$\bar{3}$ 2432.63	1	$0(1^+)$	2455.91	0	$D_{s1}(2460)$
		0	$\frac{1}{2}(1^+)$	2311.24	-115.68	$D_1(2430)$
	6 2532.57 -i199.36	1	$1(1^+)$	2529.30	-238.56	(?)
		0	$\frac{1}{2}(1^+)$	Cusp (2607)	Broad	(?)
		-1	$0(1^+)$	Cusp (2503)	Broad	(?)
	$\bar{3}$ 2535.07 -i0.08	1	$0(1^+)$	2573.62	-0.07 [-0.07]	$D_{s1}(2536)$
		0	$\frac{1}{2}(1^+)$	2526.47	-0.08 [-13]	$D_1(2420)$
	6 Cusp (2700) Narrow	1	$1(1^+)$	2756.52	-32.95 [cusp]	(?)
		0	$\frac{1}{2}(1^+)$	2750.22	-99.91 [-101]	(?)
		-1	$0(1^+)$	2756.08	-2.15 [-92]	(?)
0	1 1055.77	0	$0^-(1^{+-})$	925.12	-24.61	$h_1(1170)$
	8 1161.06	1	$\frac{1}{2}(1^+)$	1101.72	-56.27	$K_1(1270)$
		0	$1^+(1^{+-})$	1230.15	-47.02	$b_1(1235)$
			$0^-(1^{+-})$	1213.00	-5.67	$h_1(1380)$
	1 3867.59	0	$0^+(1^{++})$	3837.57	-0.00	$X(3872)$
	8 1161.37	1	$\frac{1}{2}(1^+)$	1213.20	-0.89	$K_1(1270)$
		0	$1^-(1^{++})$	1012.95	-89.77	$a_1(1260)$
			$0^+(1^{++})$	1292.96	0	$f_1(1285)$
	1 3864.62 -i0.00	0	$0^-(1^{+-})$	3840.69	-1.60	(?)

RESULTS

Results in brackets When considering finite width of ρ and K* mesons

Light states, a1 b1 … first studied by Kolomeitsev and Lutz, later by Roca, Singh, E. O.

Hidden charm predicted states. They are nearly degenerate but with opposite C-parity.

K.Terasaki, 07 also advocates for two different C-parity states

X(3872) state S=0, $0^+(1^{++})$. Qualitative discussion: take the main channel, Dbar D* - cc , and separate $|D^0\bar{D}^{*0}\rangle$ $|D^+D^{*-}\rangle$ as channels 1 and 2

$$V = \begin{pmatrix} v & v \\ v & v \end{pmatrix} \qquad T = \frac{V}{1 - vG_{11} - vG_{22}}$$

$$T_{ij} = \frac{g_i g_j}{s - s_R}$$

$$\lim_{s\to s_R} (s - s_R) T_{ij} = \lim_{s\to s_R} (s - s_R) \frac{V_{ij}}{1 - vG_{11} - vG_{22}}$$

$$\lim_{s\to s_R} (s - s_R) T_{ij} = \frac{V_{ij}}{-v(\frac{dG_{11}}{ds} + \frac{dG_{22}}{ds})}$$

The coupling of the resonance to the two channels is the same

One could interpret is as having a wave function:

DD*bar(I=0)=D^0D^{*0}bar+D^+D^{*-} +cc, which would correspond to I=0

But wait, wave functions in coordinate space need care: coming later

Isospin breaking in the X(3872) resonance

Daniel Gamermann and E. Oset, Phys. Rev. D

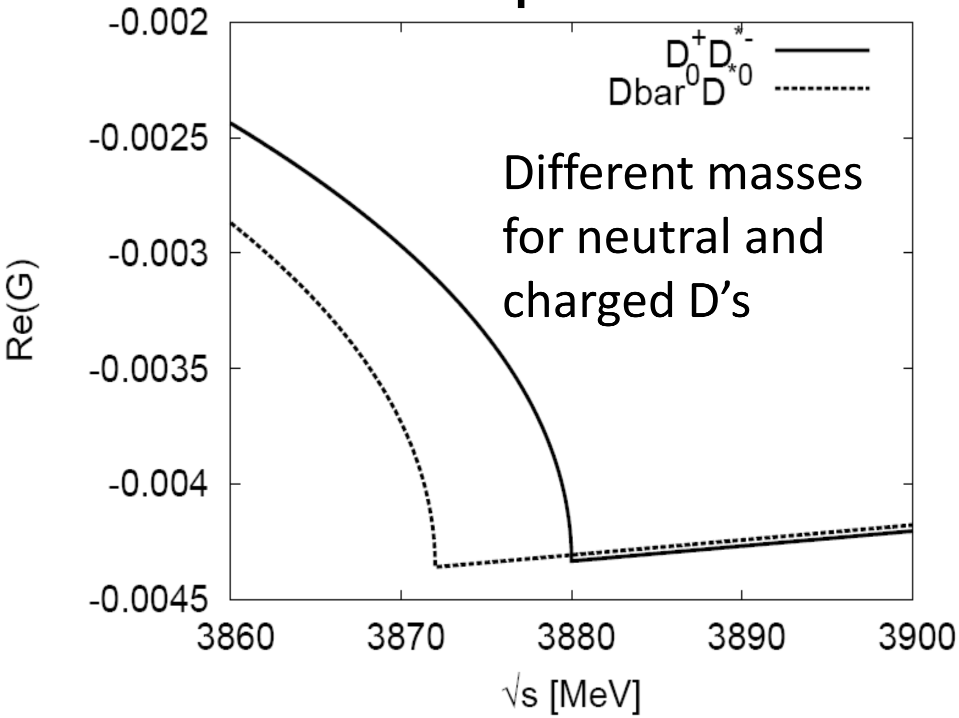
ω

DD*bar(I=0)=$D^0 D^{*0}$bar+$D^+ D^{*-}$ +cc

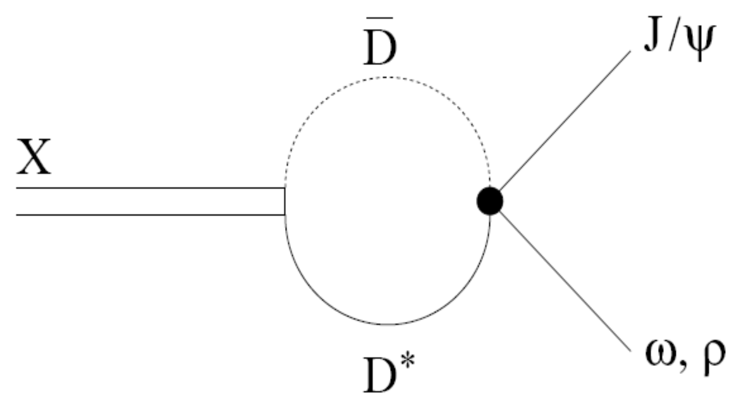
$$\frac{\mathcal{B}(X \to J/\psi\pi^+\pi^-\pi^0)}{\mathcal{B}(X \to J/\psi\pi^+\pi^-)} = 1.0 \pm 0.4 \pm 0.3$$

Violation of G-parity→ isospin

ρ



$$R_{\rho/\omega} = \left(\frac{G_{11} - G_{22}}{G_{11} + G_{22}}\right)^2$$



Many works consider X(3872) as a bound state of $D^0 D^{*0}$ E. Swanson, E. Braaten, Lyubovitskij, Dong, Gutsche ….

We perform a coupled channel approach with different masses for $D^0 D^{*0}$ and $D^+ D^{*-}$ (and cc of both). The result is that even

if the binding energy of $D^0 D^{*0}$ is very small one still has a very good I=0 wave function.

$$R_{\rho/\omega} = 0.032$$ With fixed masses of ρ and ω

Considering the mass distributions of ρ and ω

$$\frac{\mathcal{B}(X \to J/\psi\pi\pi)}{\mathcal{B}(X \to J/\psi\pi\pi\pi)} = \left(\frac{G_{11} - G_{22}}{G_{11} + G_{22}}\right)^2 \frac{\int_0^\infty q\mathcal{S}\left(s, m_\rho, \Gamma_\rho\right)\theta\left(m_X - m_{J/\psi} - \sqrt{s}\right)\, ds}{\int_0^\infty q\mathcal{S}\left(s, m_\omega, \Gamma_\omega\right)\theta\left(m_X - m_{J/\psi} - \sqrt{s}\right)\, ds}\frac{\mathcal{B}_\rho}{\mathcal{B}_\omega}$$

$$\frac{\mathcal{B}(X \to J/\psi\pi^+\pi^-\pi^0)}{\mathcal{B}(X \to J/\psi\pi^+\pi^-)} = 1.4$$

We can describe this ratio with no isospin breaking of the X(3872) wave function

If we had only $D^0 D^{*0}$ that ratio would be 50 times smaller !!

Wave functions in momentum and coordinate space

$$\langle \vec{p}\,'|V|\vec{p}\rangle = V(\vec{p}\,',\vec{p}) = v\,\Theta(\Lambda - p)\Theta(\Lambda - p') \qquad v = \begin{pmatrix} \hat{v} & \hat{v} \\ \hat{v} & \hat{v} \end{pmatrix}$$

$$T = V + V\frac{1}{E - H_0}T \longrightarrow \langle \vec{p}|T|\vec{p}\,'\rangle = \Theta(\Lambda - p)\Theta(\Lambda - p')\,t$$

$$t = (1 - vG)^{-1}v \longrightarrow G = \begin{pmatrix} G_{11} & 0 \\ 0 & G_{22} \end{pmatrix}, \quad G_{ii} = \int_{p<\Lambda} \frac{d^3p}{E - M_i - \frac{\vec{p}^{\,2}}{2\mu_i}}$$

$$= \frac{1}{1 - \hat{v}G_{11} - \hat{v}G_{22}}v \longrightarrow g_1^2 = g_2^2 \equiv g^2 = \lim_{E \to E_\alpha}(E - E_\alpha)t_{ij}$$

$$= -\left(\frac{dG_{11}}{dE} + \frac{dG_{22}}{dE}\right)^{-1}\Bigg|_{E=E_\alpha}$$

$$(H_0 + V)|\psi\rangle = E|\psi\rangle$$

$$|\psi\rangle = \begin{pmatrix} |\psi_1\rangle \\ |\psi_2\rangle \end{pmatrix} \longrightarrow$$

$$\langle \vec{p}|\psi_1\rangle = \frac{1}{G_{11}^{\alpha}}\frac{\Theta(\Lambda - p)}{E_\alpha - M_1 - \frac{\vec{p}^{\,2}}{2\mu_1}}\int_{k<\Lambda} d^3k\langle \vec{k}|\psi_1\rangle$$

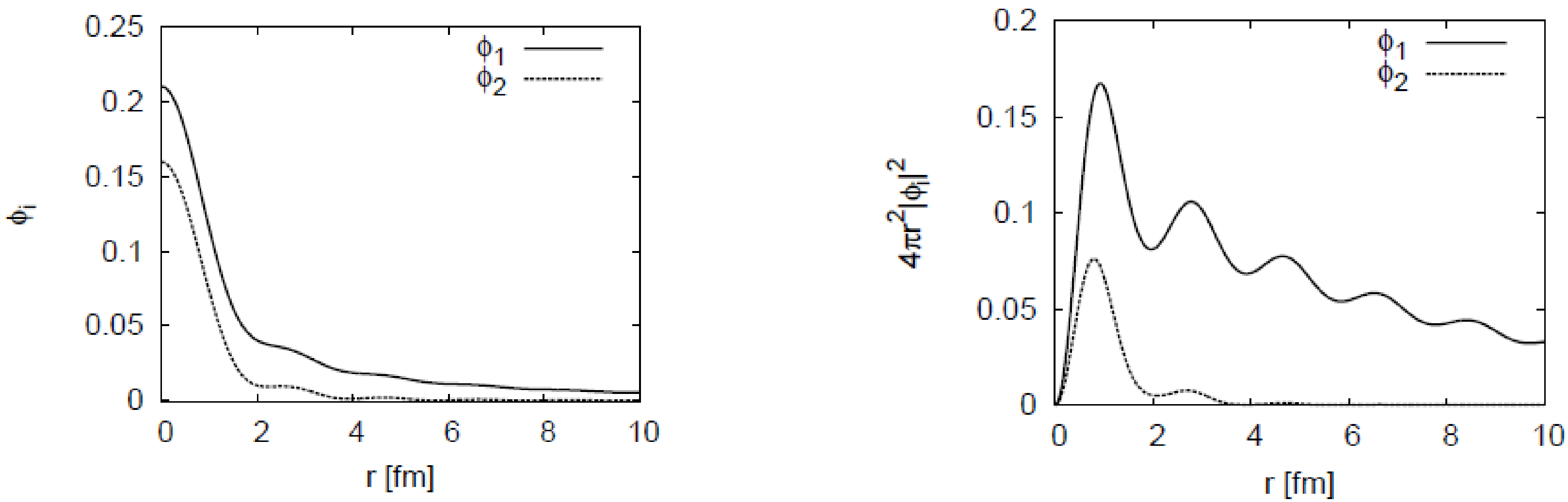
$$\langle \vec{p}|\psi_2\rangle = \frac{1}{G_{11}^{\alpha}}\frac{\Theta(\Lambda - p)}{E_\alpha - M_2 - \frac{\vec{p}^{\,2}}{2\mu_2}}\int_{k<\Lambda} d^3k\langle \vec{k}|\psi_1\rangle$$

$$\langle \vec{x}|\psi\rangle = \int d^3p\langle \vec{x}|\vec{p}\rangle\langle \vec{p}|\psi\rangle$$

$$= \int \frac{d^3p}{(2\pi)^{3/2}}e^{i\vec{p}.\vec{x}}\langle \vec{p}|\psi\rangle. \longrightarrow$$

$$gG_{11}^{\alpha} = (2\pi)^{3/2}\psi_1(\vec{0}\,) = \hat{\psi}_1$$

$$gG_{22}^{\alpha} = (2\pi)^{3/2}\psi_2(\vec{0}\,) = \hat{\psi}_2$$



Neutral and charged Wave function components for a $D^0\bar{D}^{*0}$ binding energy of 0.1 MeV.

$$\langle \vec{x}|\psi_1\rangle_{r\to\infty} \sim \frac{A_1}{\sqrt{4\pi r}} e^{-\gamma_1 r}$$

$$\langle \vec{x}|\psi_2\rangle_{r\to\infty} \sim \frac{A_2}{\sqrt{4\pi r}} e^{-\gamma_2 r}$$

$$\gamma_i = \sqrt{2\mu_i E^{\alpha}_{Bi}}$$

$$E^{\alpha}_{Bi} = M_i - E_\alpha .$$

The wave functions at the origin for the neutral and charged components are very similar: for short range interactions of the strong interaction this is what matters and what determines the isospin of the state.

It does not matter that the probability of the neutral component is much bigger.

Hidden charm states from the interaction of vector mesons

R. Molina, E. Oset PRD 2010

We take the vectors of the table, use the hidden gauge Lagrangians and study their interaction in the coupled channel unitary approach. We get three states around 3940 MeV with 0^{++},1^{++},2^{++}, and one around 4160 MeV with 2^{++}

$$T_{ij} = \frac{g_i g_j}{s - s_R}$$

We look for poles of the T-matrix, the residues give the couplings of the resonance to channels

1)

$$\sqrt{s}_{pole} = 3922 + i26,\ I^G[J^{PC}] = 0^+[2^{++}]$$

$D^*\bar{D}^*$	$D_s^*\bar{D}_s^*$	$K^*\bar{K}^*$	$\rho\rho$	$\omega\omega$
$21100 - i1802$	$1633 + i6797$	$42 + i14$	$-75 + i37$	$1558 + i1821$

$\phi\phi$	$J/\psi J/\psi$	$\omega J/\psi$	$\phi J/\psi$	$\omega\phi$
$-904 - i1783$	$1783 + i197$	$-2558 - i2289$	$918 + i2921$	$91 - i784$

To be associated with Z(3930) of Belle, seen in γγ→D barD 0^{++},2^{++} but 2^{++} preferred because of angular correla-tions

2)

$$\sqrt{s}_{pole} = 3943 + i7.4,\ I^G[J^{PC}] = 0^+[0^{++}]$$

D^*D^*	$D_s^*D_s^*$	K^*K^*	$\rho\rho$	$\omega\omega$
$18810 - i682$	$8426 + i1933$	$10 - i11$	$-22 + i47$	$1348 + i234$

$\phi\phi$	$J/\psi J/\psi$	$\omega J/\psi$	$\phi J/\psi$	$\omega\phi$
$-1000 - i150$	$417 + i64$	$-1429 - i216$	$889 + i196$	$-215 - i107$

3)

$$\sqrt{s}_{pole} = 3945 + i0,\ I^G[J^{PC}] = 0^-[1^{+-}]$$

D^*D^*	$D_s^*D_s^*$	K^*K^*	$\rho\rho$	$\omega\omega$	$\phi\phi$	$J/\psi J/\psi$	$\omega J/\psi$	$\phi J/\psi$	$\omega\phi$
$18489 - i0.78$	$8763 + i2$	$11 - i38$	0	0	0	0	0	0	0

4)

$$\sqrt{s}_{pole} = 3919 + i74,\ I^G[J^{PC}] = 1^-[2^{++}]$$

$D^*\bar{D}^*$	$K^*\bar{K}^*$	$\rho\rho$	$\rho\omega$	$\rho J/\psi$	$\rho\phi$
$20267 - i4975$	$148 - i33$	0	$-1150 - i3470$	$2105 + i5978$	$-1067 - i2514$

5)

$$\sqrt{s}_{pole} = 4169 + i66,\ I^G[J^{PC}] = 0^+[2^{++}]$$

$D^*\bar{D}^*$	$D_s^*\bar{D}_s^*$	$K^*\bar{K}^*$	$\rho\rho$	$\omega\omega$
$1225 - i490$	$18927 - i5524$	$-82 + i30$	$70 + i20$	$3 - i2441$

$\phi\phi$	$J/\psi J/\psi$	$\omega J/\psi$	$\phi J/\psi$	$\omega\phi$
$1257 + i2866$	$2681 + i940$	$-866 + i2752$	$-2617 - i5151$	$1012 + i1522$

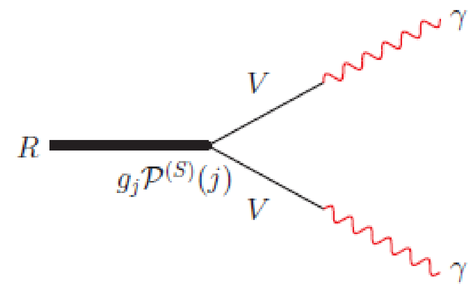
State	M (MeV)	Γ (MeV)	J^{PC}	Decay modes	Production modes
$Z(3940)$	3929 ± 5	29 ± 10	2^{++}	$D\bar{D}$	$\gamma\gamma$
$X(3940)$	3942 ± 9	37 ± 17	J^{P+}	$D\bar{D}^*$	$e^+e^- \to J/\psi X(3940)$
$Y(3940)$	3943 ± 17	87 ± 34	J^{P+}	$\omega J/\psi$	$B \to KY(3940)$
	$3914.3^{+4.1}_{-3.8}$	33^{+12}_{-8}			
$X(4160)$	4156 ± 29	139^{+113}_{-65}	J^{P+}	$D^*\bar{D}^*$	$e^+e^- \to J/\psi X(4160)$

$I^G[J^{PC}]$	Theory		Experiment			
	Mass [MeV]	Width [MeV]	Name	Mass [MeV]	Width [MeV]	J^{PC}
$0^+[0^{++}]$	3943	17	$Y(3940)$	3943 ± 17	87 ± 34	J^{P+}
				$3914.3^{+4.1}_{-3.8}$	33^{+12}_{-8}	
$0^-[1^{+-}]$	3945	0	"$Y_p(3945)$"			
$0^+[2^{++}]$	3922	55	$Z(3930)$	3929 ± 5	29 ± 10	2^{++}
$0^+[2^{++}]$	4157	102	$X(4160)$	4156 ± 29	139^{+113}_{-65}	J^{P+}
$1^-[2^{++}]$	3912	120	"$Y_p(3912)$"			

the X(4160)

This state also described as D_s* D_s*bar in Dong, Lyubovitskij, Gutsche, T, Branz ….using the Weinberg compositeness method.

Radiative decay of
The X,Y,Z states , T. Branz, R. Molina, E. O.



Channel	pole positions and $I^G[J^{PC}]$		
	$3943 + i7.4,\ 0^+[0^{++}]$	$3922 + i26,\ 0^+[2^{++}]$	$4169 + i66,\ 0^+[2^{++}]$
$\rho\rho$	$-22 + i47$	$-75 + i37$	$70 + i20$
$\omega\omega$	$1348 + i234$	$1558 + i1821$	$3 - i2441$
$\phi\phi$	$-1000 - i150$	$-904 - i1783$	$1257 + i2866$
$J/\psi J/\psi$	$417 + i64$	$1783 + i197$	$2681 + i940$
$\omega\phi$	$-215 - i107$	$91 - i784$	$1012 + i1522$
$\omega J/\psi$	$-1429 - i216$	$-2558 - i2289$	$-866 + i2752$
$\phi J/\psi$	$889 + i196$	$918 + i2921$	$-2617 - i5151$

TABLE I: Couplings g_i in units of MeV for the resonances with $I = 0$.

pole [MeV]	$I^G\, J^{PC}$	meson	$\Gamma_{\rho\gamma}$[KeV]	$\Gamma_{\omega\gamma}$[KeV]	$\Gamma_{\phi\gamma}$[KeV]	$\Gamma_{J/\psi\gamma}$[KeV]	$\Gamma_{\gamma\gamma}$[KeV]
$(3943, +i7.4)$	$0^+\,(0^{++})$	$Y(3940)$	0.015	0.989	13.629	0.722	0.013
$(3922, +i26)$	$0^+\,(2^{++})$	$Z(3930)$	0.040	15.155	95.647	13.952	0.083
$(4169, +i66)$	$0^+\,(2^{++})$	$X(4160)$	0.029	10.659	268.854	125.529	0.363
$(3919, +i74)$	$1^-\,(2^{++})$	$'Y_p(3912)'$	201.458	114.561	62.091	135.479	0.774

pole [MeV]	$I^G\, J^{PC}$	meson	$\Gamma_{\gamma\gamma}^{\rm new}$[KeV]
$(3943, +i7.4)$	$0^+\,(0^{++})$	$Y(3940)$	0.085
$(3922, +i26)$	$0^+\,(2^{++})$	$Z(3930)$	0.074
$(4169, +i66)$	$0^+\,(2^{++})$	$X(4160)$	0.54
$(3919, +i74)$	$1^-\,(2^{++})$	$'Y_p(3912)'$	1.11

Belle Collaboration, S. Uehara, PRL 2010

$$\Gamma_{\gamma\gamma}(X(3915))\mathcal{B}(X(3915)\to\omega J/\psi) = \begin{cases} (61\pm17\pm8)\ \mathbf{eV} & \mathbf{for}\ J^P = 0^+ \\ (18\pm5\pm2)\ \mathbf{eV} & \mathbf{for}\ J^P = 2^+ \end{cases}$$

We can calculate

$$\Gamma_{\omega J/\psi(0^+,3943)} = 1.52\ \mathrm{MeV}$$

$$\Gamma_{\omega J/\psi(2^+,3922)} = 8.66\ \mathrm{MeV}\,.$$

And also

$$\Gamma_{\gamma\gamma}\mathcal{B}((0^+,3943)\to\omega J/\psi) = 7.6\ \mathbf{eV}$$

$$\Gamma_{\gamma\gamma}\mathcal{B}((2^+,3922)\to\omega J/\psi) = 11.8\ \mathbf{eV}$$

The state with 2^+ is clearly preferred by these data.

Conclusions:

The X(3872) as a $0^{+}(1^{++})$ state of D Dbar*, requires the charged and neutral components. Their wave functions at small distances are similar → determines the I=0 character of this resonance.

Some of the X,Y,Z states around 4000 MeV can be acommodated as V-V molecules with hidden charm: masses, widths and partial decay widths seem to match within the limited experimental information.