Определение интенсивности распада $X(3872) \to D^0 \bar{D}^{*0} + D^{*0} \bar{D}^0$

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X(3872)

X(3872) Belle Collaboration, 2003

$X \rightarrow J/\psi(1S)\pi^+\pi^-$

$X \rightarrow J/\psi(1S)\pi^+\pi^-\pi^0$

$X \rightarrow D^{*0}\bar{D}^0 + c.c.$

$M_X \approx M_{D^{*0}} + M_{D^0}$

X(3872) 1^{++}

$$L(x) = g_A X^\mu \Big(D_\mu(x)\bar{D}(x) + \bar{D}_\mu(x) D(x) \Big)$$

The width of the $X \to D^{*0}\bar{D}^0 + c.c.$ decay

$$\Gamma(X \to D^{*0}\bar{D}^0 + c.c.\,,\ m) = \frac{g_A^2}{8\pi}\frac{\rho(m)}{m}\left(1 + \frac{\mathbf{k}^2}{3m_{D^{*0}}^2}\right),$$

where

$$\rho(m) = \frac{2|\mathbf{k}|}{m} = \frac{\sqrt{(m^2 - m_+^2)(m^2 - m_-^2)}}{m^2}, \qquad m_\pm = m_{D^{*0}} \pm m_{D^0}\,.$$

Spectrum

The mass spectrum in the $D^{*0}\bar{D}^0 + c.c.$ channel

$$\frac{dBR(X \to D^{*0}\bar{D}^0 + c.c.\,,\, m)}{dm} = 4\frac{1}{\pi}\frac{m^2\Gamma(X \to D^{*0}\bar{D}^0,\, m)}{|D_X(m)|^2}. \quad (1)$$

In others $\{i\}$ (non-$D^{*0}\bar{D}$) channels the $X(3872)$ state is seen as a narrow resonance

$$\frac{dBR(X \to i\,,\, m)}{dm} = 2\frac{1}{\pi}\frac{m_X^2\,\Gamma_i}{|D_X(m)|^2}\,, \quad (2)$$

where Γ_i is the width of the $X(3872) \to i$ decay.

$$D_X(m) = m_X^2 - m^2 + Re(\Pi_X(m_X)) - \Pi_X(m) - \imath m_X \Gamma\,, \qquad (3)$$

unitarity:

$$BR(X \to D^{*0}\bar{D}^0 + c.c.) + \sum_i BR(X \to i) = 1$$

where $\Gamma = \Sigma\Gamma_i$ is the total width of the $X(3872)$ decay into all non-$D^{*0}\bar{D}$ channels.

When $m_+ \leq m$,

$$\Pi_X(m) =$$

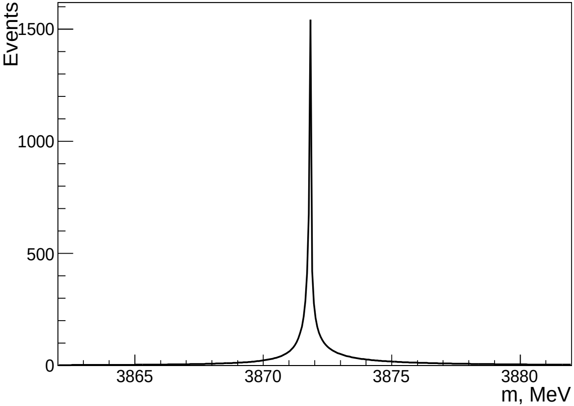
$$\frac{g_A^2}{8\pi^2}\left\{\frac{(m^2-m_+^2)}{m^2}\frac{m_-}{m_+}\ln\frac{m_{D^{*0}}}{m_{D^0}} + \rho(m)\left[\imath\pi + \ln\frac{\sqrt{m^2-m_-^2}-\sqrt{m^2-m_+^2}}{\sqrt{m^2-m_-^2}+\sqrt{m^2-m_+^2}}\right]\right\}$$

When $m_- \leq m \leq m_+$, $\Pi_X(m) =$

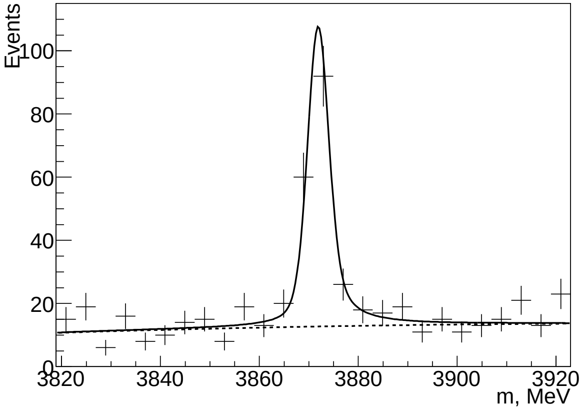
$$\frac{g_A^2}{8\pi^2}\left\{\frac{(m^2-m_+^2)}{m^2}\frac{m_-}{m_+}\ln\frac{m_{D^{*0}}}{m_{D^0}} - 2|\rho(m)|\arctan\frac{\sqrt{m^2-m_-^2}}{\sqrt{m_+^2-m^2}}\right\},$$

where $|\rho(m)| = \sqrt{(m_+^2-m^2)(m^2-m_-^2)}/m^2$.
When $m \leq m_-$ and $m^2 \leq 0$, $\Pi_X(m) =$

$$\frac{g_A^2}{8\pi^2}\left\{\frac{(m^2-m_+^2)}{m^2}\frac{m_-}{m_+}\ln\frac{m_{D^{*0}}}{m_{D^0}} - \rho(m)\ln\frac{\sqrt{m_+^2-m^2}-\sqrt{m_-^2-m^2}}{\sqrt{m_+^2-m^2}+\sqrt{m_-^2-m^2}}\right\}$$


Events
1500
1000
500
0
3865
3870
3875
3880
m, MeV

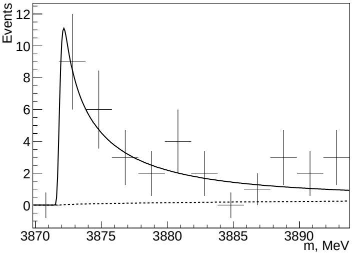
$B^+ \to K^+ X(3872)$ (Belle)
$X \to J/\psi(1S)\pi^+\pi^-$



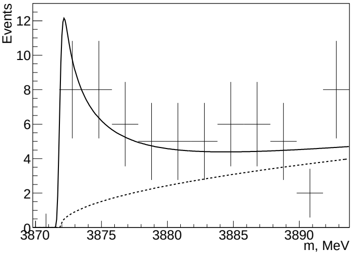
$\mathrm{M}(J/\psi(1S)\pi^+\pi^-)$

Data

$B \to KX(3872)$ (Belle)
$X \to D^{*0}\bar{D}^0 + c.c.$



$D^{*0} \to D^0\pi^0$



$D^{*0} \to D^0\gamma$

$M(D^*D)$

$BR(B \to XK) \times BR(X \to D^{*0}\bar{D}^0) = (0.80 \pm 0.20 \pm 0.10) \times 10^{-4}$
$BR(B^+ \to XK^+) \times BR(X \to \pi^+\pi^- J/\psi(1S)) = (8.61 \pm 0.82 \pm 0.52) \times 10^{-6}$
$BR(B^+ \to XK^+) \times BR(X \to \pi^+\pi^-\pi^0 J/\psi(1S)) = (0.6 \pm 0.2 \pm 0.1) \times 10^{-5}$
$BR(B^+ \to XK^+) \times BR(X \to \gamma J/\psi(1S)) = (1.78^{+0.48}_{-0.44} \pm 0.12) \times 10^{-6}$

$BR(X \to D^{*0}\bar{D}^0 + c.c.; m \le 3892\,\mathrm{MeV})$ is nearly 5-2.5 times as large as the sum of all other known branching ratios.That consistent with results:

Γ	$g_A^2/8\pi$	χ^2/Ndf	$\mathcal{B}_{seen}$	$\mathcal{B}$	$\mathcal{B}(Oth)_{seen}$
$1.2_{-0.467}$	$0.857^{+3.614}_{-0.481}$	$43.74/42$	$0.486^{+0.061}_{-0.29}$	$0.795^{+0.19}_{-0.224}$	$0.191^{+0.223}_{-0.179}$

For parameters in L. Maiani et al., Phys. Rev. D **87**,111102(R) (2013) unknown decays $X(3872)$ into non-$D^{*0}\bar{D}^0$ states are dominant:

M_X	Γ	$g_A^2/8\pi$	$\mathcal{B}_{seen}$	$\mathcal{B}$	$\mathcal{B}(Oth)_{seen}$
3871.68	1.2	0.1	0.152	0.189	0.792