

$\psi(4360)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

I needs confirmation.

also known as $Y(4360)$; was $X(4360)$

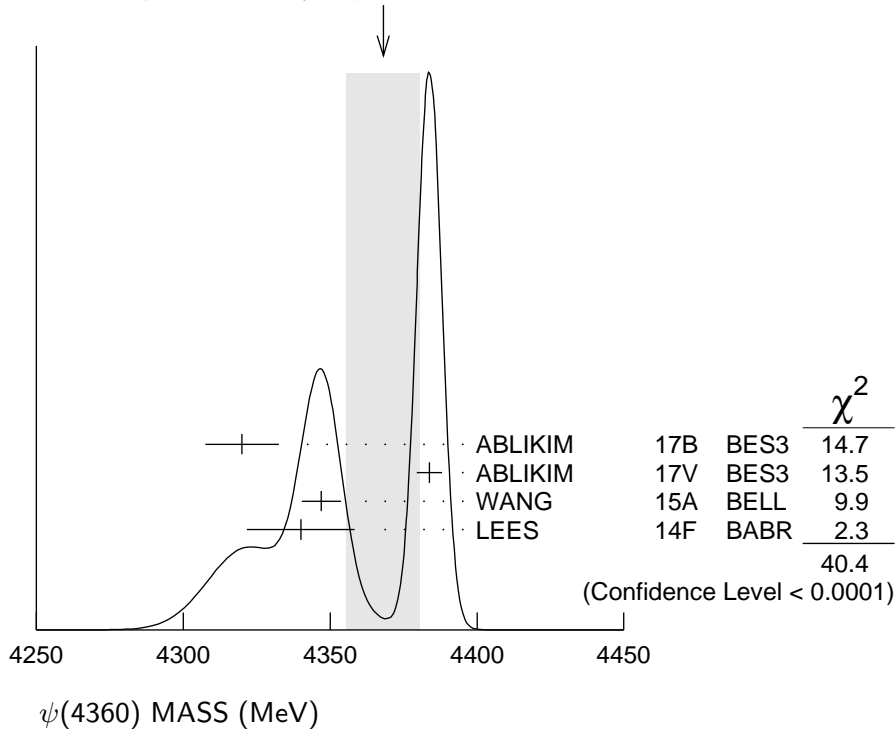
This state shows properties different from a conventional $q\bar{q}$ state. A candidate for an exotic structure. See the review on non- $q\bar{q}$ states.

Seen in radiative return from e^+e^- collisions at $\sqrt{s} = 9.54\text{--}10.58$ GeV by AUBERT 07S, WANG 07D, and LEES 14F. See also the review on "Spectroscopy of mesons containing two heavy quarks."

$\psi(4360)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
4368 ±13	OUR AVERAGE	Error includes scale factor of 3.7. See the ideogram below.		
4320.0 ±10.4 ±7.0		¹ ABLIKIM 17B	BES3	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$
4383.8 ± 4.2 ±0.8		² ABLIKIM 17V	BES3	$e^+e^- \rightarrow \pi^+\pi^- \psi(2S)$
4347 ± 6 ±3	279	³ WANG 15A	BELL	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
4340 ±16 ±9	37	⁴ LEES 14F	BABR	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
4383.7 ± 2.9 ±6.2		⁵ ZHANG 17B	RVUE	$e^+e^- \rightarrow \pi^+\pi^- \psi(2S)$
4386.4 ± 2.1 ±6.4		⁶ ZHANG 17C	RVUE	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$ or $\psi(2S)$
4355 $\begin{smallmatrix} +9 \\ -10 \end{smallmatrix}$ ±9	74	⁷ LIU 08H	RVUE	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
4324 ±24		⁸ AUBERT 07S	BABR	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$
4361 ± 9 ±9	47	⁴ WANG 07D	BELL	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^- \psi(2S)$

WEIGHTED AVERAGE
4368±13 (Error scaled by 3.7)



- ¹ From a three-resonance fit.
² From a fit to the cross section for $e^+e^- \rightarrow \pi^+\pi^-\psi(2S) \rightarrow 2(\pi^+\pi^-)\ell^+\ell^-$ obtained from 16 center-of-mass energies between 4.008 and 4.600 GeV and comprising 5.1 fb^{-1} .
³ From a two-resonance fit. Supersedes WANG 07D.
⁴ From a two-resonance fit.
⁵ From a three-resonance fit.
⁶ From a combined fit of BELLE, BABAR and BES3 $e^+e^- \rightarrow \pi^+\pi^-J/\psi$ and $e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$ data.
⁷ From a combined fit of AUBERT 07S and WANG 07D data with two resonances.
⁸ From a single-resonance fit. Systematic errors not estimated.

$\psi(4360)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
96 ± 7 OUR AVERAGE				
$101.4^{+25.3}_{-19.7} \pm 10.2$		¹ ABLIKIM 17B	BES3	$e^+e^- \rightarrow \pi^+\pi^-J/\psi$
$84.2 \pm 12.5 \pm 2.1$		² ABLIKIM 17V	BES3	$e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$
$103 \pm 9 \pm 5$	279	³ WANG 15A	BELL	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
$94 \pm 32 \pm 13$	37	⁴ LEES 14F	BABR	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$94.2 \pm 7.3 \pm 2.0$		⁵ ZHANG 17B	RVUE	$e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$
$96.0 \pm 6.7 \pm 2.7$		⁶ ZHANG 17C	RVUE	$e^+e^- \rightarrow \pi^+\pi^-J/\psi$ or $\psi(2S)$
$103^{+17}_{-15} \pm 11$	74	⁷ LIU 08H	RVUE	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
172 ± 33		⁸ AUBERT 07S	BABR	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$
$74 \pm 15 \pm 10$	47	⁴ WANG 07D	BELL	$10.58 e^+e^- \rightarrow \gamma\pi^+\pi^-\psi(2S)$

- ¹ From a three-resonance fit.
² From a fit to the cross section for $e^+e^- \rightarrow \pi^+\pi^-\psi(2S) \rightarrow 2(\pi^+\pi^-)\ell^+\ell^-$ obtained from 16 center-of-mass energies between 4.008 and 4.600 GeV and comprising 5.1 fb^{-1} .
³ From a two-resonance fit. Supersedes WANG 07D.
⁴ From a two-resonance fit.
⁵ From a three-resonance fit.
⁶ From a combined fit of BELLE, BABAR and BES3 $e^+e^- \rightarrow \pi^+\pi^-J/\psi$ and $e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$ data.
⁷ From a combined fit of AUBERT 07S and WANG 07D data with two resonances.
⁸ From a single-resonance fit. Systematic errors not estimated.

$\psi(4360)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 e^+e^-	
Γ_2 $J/\psi\pi^+\pi^-$	
Γ_3 $\psi(2S)\pi^+\pi^-$	seen
Γ_4 $\psi_2(3823)\pi^+\pi^-$	possibly seen
Γ_5 $J/\psi\eta$	
Γ_6 $D^0D^{*-}\pi^+$	
Γ_7 $\chi_{c1}\gamma$	
Γ_8 $\chi_{c2}\gamma$	

$\psi(4360) \Gamma(i) \times \Gamma(e^+ e^-) / \Gamma(\text{total})$ $\Gamma(\psi(2S)\pi^+\pi^-) \times \Gamma(e^+ e^-) / \Gamma_{\text{total}} \quad \Gamma_3 \Gamma_1 / \Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$9.2 \pm 0.6 \pm 0.6$	279	¹ WANG	15A BELL	$10.58 e^+ e^- \rightarrow \gamma \pi^+ \pi^- \psi(2S)$
$10.9 \pm 0.6 \pm 0.7$	279	² WANG	15A BELL	$10.58 e^+ e^- \rightarrow \gamma \pi^+ \pi^- \psi(2S)$
$6.0 \pm 1.0 \pm 0.5$	37	³ LEES	14F BABR	$10.58 e^+ e^- \rightarrow \gamma \pi^+ \pi^- \psi(2S)$
$7.2 \pm 1.0 \pm 0.6$	37	⁴ LEES	14F BABR	$10.58 e^+ e^- \rightarrow \gamma \pi^+ \pi^- \psi(2S)$
$11.1^{+1.3}_{-1.2}$	74	⁵ LIU	08H RVUE	$10.58 e^+ e^- \rightarrow \gamma \pi^+ \pi^- \psi(2S)$
12.3 ± 1.2	74	⁶ LIU	08H RVUE	$10.58 e^+ e^- \rightarrow \gamma \pi^+ \pi^- \psi(2S)$
$10.4 \pm 1.7 \pm 1.5$	47	³ WANG	07D BELL	$10.58 e^+ e^- \rightarrow \gamma \pi^+ \pi^- \psi(2S)$
$11.8 \pm 1.8 \pm 1.4$	47	⁴ WANG	07D BELL	$10.58 e^+ e^- \rightarrow \gamma \pi^+ \pi^- \psi(2S)$

¹ Solution I of two equivalent solutions from a fit using two interfering resonances. Supersedes WANG 07D.

² Solution II of two equivalent solutions from a fit using two interfering resonances. Supersedes WANG 07D.

³ Solution I of two equivalent solutions in a fit using two interfering resonances.

⁴ Solution II of two equivalent solutions in a fit using two interfering resonances.

⁵ Solution I in a combined fit of AUBERT 07S and WANG 07D data with two resonances.

⁶ Solution II in a combined fit of AUBERT 07S and WANG 07D data with two resonances.

 $\Gamma(J/\psi\eta) \times \Gamma(e^+ e^-) / \Gamma_{\text{total}} \quad \Gamma_5 \Gamma_1 / \Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

< 6.8	90	WANG	13B BELL	$e^+ e^- \rightarrow J/\psi \eta \gamma$
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 $\Gamma(\chi_{c1}\gamma) \times \Gamma(e^+ e^-) / \Gamma_{\text{total}} \quad \Gamma_7 \Gamma_1 / \Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
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< 0.57	90	¹ HAN	15 BELL	$10.58 e^+ e^- \rightarrow \chi_{c1} \gamma$
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¹ Using $B(\eta \rightarrow \gamma \gamma) = (39.41 \pm 0.21)\%$.

 $\Gamma(\chi_{c2}\gamma) \times \Gamma(e^+ e^-) / \Gamma_{\text{total}} \quad \Gamma_8 \Gamma_1 / \Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
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< 1.9	90	¹ HAN	15 BELL	$10.58 e^+ e^- \rightarrow \chi_{c2} \gamma$
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¹ Using $B(\eta \rightarrow \gamma \gamma) = (39.41 \pm 0.21)\%$.

 $\psi(4360)$ BRANCHING RATIOS $\Gamma(D^0 D^{*-} \pi^+) / \Gamma(\psi(2S)\pi^+\pi^-) \quad \Gamma_6 / \Gamma_3$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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< 8	90	PAKHLOVA	09 BELL	$e^+ e^- \rightarrow \psi(4360) \rightarrow D^0 D^{*-} \pi^+$
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$\Gamma(\psi(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
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seen ¹ ABLIKIM 17V BES3 $e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$

¹ From a fit to the cross section for $e^+e^- \rightarrow \pi^+\pi^-\psi(2S) \rightarrow 2(\pi^+\pi^-)\ell^+\ell^-$ obtained from 16 center-of-mass energies between 4.008 and 4.600 GeV and comprising 5.1 fb^{-1} .

$\Gamma(\psi(2S)\pi^+\pi^-)/\Gamma(J/\psi\pi^+\pi^-)$ Γ_3/Γ_2

VALUE	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$(0.81 \pm 0.12 \pm 0.13)$ to $(42 \pm 15 \pm 15)$ ¹ ZHANG 17C RVUE $e^+e^- \rightarrow \pi^+\pi^-J/\psi$ or $\psi(2S)$

¹ From a combined fit of BELLE, BABAR and BES3 $e^+e^- \rightarrow \pi^+\pi^-J/\psi$ and $e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$ data.

$\Gamma(\psi_2(3823)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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possibly seen 19 ¹ ABLIKIM 15S BES3 $e^+e^- \rightarrow \pi^+\pi^-\chi_{c1}\gamma$

¹ From a fit of $e^+e^- \rightarrow \pi^+\pi^-\psi_2(3823)$, $\psi_2(3823) \rightarrow \chi_{c1}\gamma$ cross sections taken at \sqrt{s} values of 4.23, 4.26, 4.36, 4.42, and 4.60 GeV to the $\psi(4360)$ line shape.

$\Gamma(D^0D^{*-}\pi^+)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_6/\Gamma \times \Gamma_1/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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$<0.72 \times 10^{-6}$ 90 ¹ PAKHLOVA 09 BELL $e^+e^- \rightarrow \psi(4360) \rightarrow D^0D^{*-}\pi^+$

¹ Using $4355^{+9}_{-10} \pm 9 \text{ MeV}$ for the mass of $\psi(4360)$.

$\psi(4360)$ REFERENCES

ABLIKIM	17B	PRL 118 092001	M. Ablikim <i>et al.</i>	(BES III Collab.)
ABLIKIM	17V	PR D96 032004	M. Ablikim <i>et al.</i>	(BES III Collab.)
ZHANG	17B	PR D96 054008	J. Zhang, J. Zhang	
ZHANG	17C	EPJ C77 727	J. Zhang, L. Yuan	
ABLIKIM	15S	PRL 115 011803	M. Ablikim <i>et al.</i>	(BES III Collab.)
HAN	15	PR D92 012011	Y.L. Han <i>et al.</i>	(BELLE Collab.)
WANG	15A	PR D91 112007	X.L. Wang <i>et al.</i>	(BELLE Collab.)
LEES	14F	PR D89 111103	J.P. Lees <i>et al.</i>	(BABAR Collab.)
WANG	13B	PR D87 051101	X.L. Wang <i>et al.</i>	(BELLE Collab.)
PAKHLOVA	09	PR D80 091101	G. Pakhlova <i>et al.</i>	(BELLE Collab.)
LIU	08H	PR D78 014032	Z.Q. Liu, X.S. Qin, C.Z. Yuan	
AUBERT	07S	PRL 98 212001	B. Aubert <i>et al.</i>	(BABAR Collab.)
WANG	07D	PRL 99 142002	X.L. Wang <i>et al.</i>	(BELLE Collab.)