$\psi(4040)$

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

$\psi(4040)$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
4039 ± 1 OUR ESTIMATE				
4039.6± 4.3	[1] ABLIKIM	08D	BES2	$e^+e^- \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
4034 ± 6	[2] MO	10	RVUE	$e^+e^- \to$ hadrons
4037 ± 2	[3] SETH	05A	RVUE	$e^+e^- \to$ hadrons
4040 ± 1	[4] SETH	05A	RVUE	$e^+e^- \to$ hadrons
4040 ±10	BRANDELIK	78C	DASP	e^+e^-

[1] Reanalysis of data presented in BAI 02C. From a global fit over the center-of-mass energy region 3.7–5.0 GeV covering the $\psi(3770)$, $\psi(4040)$, $\psi(4160)$, and $\psi(4415)$ resonances. Phase angle fixed in the fit to $\delta = (130 \pm 46)^\circ$.

[2] Reanalysis of data presented in BAI 00 and BAI 02C. From a global fit over the center-of-mass energy 3.8-4.8 GeV covering the $\psi(4040)$, $\psi(4160)$ and $\psi(4415)$ resonances and including interference effects.

[3] From a fit to Crystal Ball (OSTERHELD 86) data.

[4] From a fit to BES (BAI 02C) data.

$\psi(4040)$ WIDTH

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
80 ±10 OUR ESTIMATE				
84.5±12.3	[5] ABLIKIM	08D	BES2	$e^+e^- \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
87 ±11	[6] MO	10	RVUE	$e^+e^- \to$ hadrons
85 ±10	[7] SETH	05A	RVUE	$e^+e^- \to$ hadrons
89 ± 6	[8] SETH	05A	RVUE	$e^+e^- \to$ hadrons
52 ±10	BRANDELIK	78C	DASP	e^+e^-

[5] Reanalysis of data presented in BAI 02C. From a global fit over the center-of-mass energy region 3.7–5.0 GeV covering the $\psi(3770)$, $\psi(4040)$, $\psi(4160)$, and $\psi(4415)$ resonances. Phase angle fixed in the fit to $\delta = (130 \pm 46)^\circ$.

[6] Reanalysis of data presented in BAI 00 and BAI 02C. From a global fit over the center-of-mass energy 3.8-4.8 GeV covering the $\psi(4040)$, $\psi(4160)$ and $\psi(4415)$ resonances and including interference effects.

[7] From a fit to Crystal Ball (OSTERHELD 86) data.

[8] From a fit to BES (BAI 02C) data.

$\psi(4040)$ DECAY MODES

Due to the complexity of the $c\overline{c}$ threshold region, in this listing, "seen" ("not seen") means that a cross section for the mode in question has been measured at effective $\sqrt{s}$ near this particle's central mass value, more (less) than 2σ above zero, without regard to any peaking behavior in $\sqrt{s}$ or absence thereof. See mode listing(s) for details and references.

	Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1	e^+e^-	$(1.07\pm0.16)\times10^{-5}$	
Γ_2	$D\overline{D}$	seen	
Γ_3	$D^0\overline{D}^0$	seen	
Γ_4	D^+D^-	seen	
Γ_5	$D^*\overline{D}+$ c.c.	seen	
Γ_6	$D^*(2007)^0\overline{D}^0+$ c.c.	seen	
Γ_7	$D^*(2010)^+D^-+$ c.c.	seen	
Γ_8	$D^*\overline{D}^*$	seen	
Γ_9	$D^*(2007)^0\overline{D}^*(2007)^0$	seen	
Γ_{10}	$D^*(2010)^+D^*(2010)^-$	seen	
Γ_{11}	$D\overline{D}\pi$ (excl. $D^*\overline{D}$)		
Γ_{12}	$D^0D^-\pi^+$+c.c. (excl. $D^*(2007)^0\overline{D}^0$ +c.c., $D^*(2010)^+D^-$ +c.c.)	not seen	
Γ_{13}	$D\overline{D}^*\pi$ (excl. $D^*\overline{D}^*$)	not seen	
Γ_{14}	$D^0\overline{D}^{*-}\pi^+$+c.c. (excl. $D^*(2010)^+D^*(2010)^-$)	seen	
Γ_{15}	$D_s^+D_s^-$	seen	
Γ_{16}	$J/\psi(1S)$ hadrons		
Γ_{17}	$J/\psi\pi^+\pi^-$	$<4\times10^{-3}$	90%
Γ_{18}	$J/\psi\pi^0\pi^0$	$<2\times10^{-3}$	90%
Γ_{19}	$J/\psi\eta$	$(5.2\pm0.7)\times10^{-3}$	
Γ_{20}	$J/\psi\pi^0$	$<2.8\times10^{-4}$	90%
Γ_{21}	$J/\psi\pi^+\pi^-\pi^0$	$<2\times10^{-3}$	90%
Γ_{22}	$\chi_{c1}\gamma$	<1.1 %	90%
Γ_{23}	$\chi_{c2}\gamma$	<1.7 %	90%
Γ_{24}	$\chi_{c1}\pi^+\pi^-\pi^0$	<1.1 %	90%
Γ_{25}	$\chi_{c2}\pi^+\pi^-\pi^0$	<3.2 %	90%
Γ_{26}	$h_c(1P)\pi^+\pi^-$	$<3\times10^{-3}$	90%
Γ_{27}	$\phi\pi^+\pi^-$	$<3\times10^{-3}$	90%
Γ_{28}	$\Lambda\overline{\Lambda}\pi^+\pi^-$	$<2.9\times10^{-4}$	90%
Γ_{29}	$\Lambda\overline{\Lambda}\pi^0$	$<9\times10^{-5}$	90%
Γ_{30}	$\Lambda\overline{\Lambda}\eta$	$<3.0\times10^{-4}$	90%
Γ_{31}	$\Sigma^+\overline{\Sigma}^-$	$<1.3\times10^{-4}$	90%
Γ_{32}	$\Sigma^0\overline{\Sigma}^0$	$<7\times10^{-5}$	90%

Γ_{33}	$\Xi^+ \overline{\Xi}^-$	< 1.6	$\times 10^{-4}$	90%
Γ_{34}	$\Xi^0 \overline{\Xi}^0$	< 1.8	$\times 10^{-4}$	90%
Γ_{35}	$\mu^+ \mu^-$			

$\psi(4040)$ PARTIAL WIDTHS

$\Gamma(e^+ e^-)$ — Γ_1

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
0.86±0.07 OUR ESTIMATE				
0.83±0.20	[9] ABLIKIM	08D	BES2	$e^+ e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.6 to 1.4	[10] MO	10	RVUE	$e^+ e^- \rightarrow$ hadrons
0.88±0.11	[11] SETH	05A	RVUE	$e^+ e^- \rightarrow$ hadrons
0.91±0.13	[12] SETH	05A	RVUE	$e^+ e^- \rightarrow$ hadrons
0.75±0.15	BRANDELIK	78C	DASP	$e^+ e^-$

[9] Reanalysis of data presented in BAI 02C. From a global fit over the center-of-mass energy region 3.7–5.0 GeV covering the $\psi(3770)$, $\psi(4040)$, $\psi(4160)$, and $\psi(4415)$ resonances. Phase angle fixed in the fit to $\delta = (130 \pm 46)^\circ$.

[10] Reanalysis of data presented in BAI 00 and BAI 02C. From a global fit over the center-of-mass energy 3.8-4.8 GeV covering the $\psi(4040)$, $\psi(4160)$ and $\psi(4415)$ resonances and including interference effects. Four sets of solutions are obtained with the same fit quality, mass and total width, but with different $e^+ e^-$ partial widths. We quote only the range of values.

[11] From a fit to Crystal Ball (OSTERHELD 86) data.

[12] From a fit to BES (BAI 02C) data.

$\psi(4040)$ $\Gamma(i)\Gamma(e^+ e^-)/\Gamma^2(\text{total})$

$\Gamma(J/\psi\eta)/\Gamma_{\text{total}} \times \Gamma(e^+ e^-)/\Gamma_{\text{total}}$ — $\Gamma_{19}/\Gamma \times \Gamma_1/\Gamma$

VALUE (units 10^{-8})	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
5.1±1.4±1.5	[13] WANG	13B	BELL	$e^+ e^- \rightarrow J/\psi\eta\gamma$
12.8±2.1±1.9	[14] WANG	13B	BELL	$e^+ e^- \rightarrow J/\psi\eta\gamma$

[13] Solution I of two equivalent solutions in a fit using two interfering resonances. Mass and width fixed at 4039 MeV and 80 MeV, respectively.

[14] Solution II of two equivalent solutions in a fit using two interfering resonances. Mass and width fixed at 4039 MeV and 80 MeV, respectively.

$\psi(4040)$ BRANCHING RATIOS

$\Gamma(e^+ e^-)/\Gamma_{\text{total}}$ — Γ_1/Γ

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$\sim$ 1.0	FELDMAN	77	MRK1	$e^+ e^-$

$\Gamma(D^0 \overline{D}^0)/\Gamma_{total}$ — Γ_3/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+ e^- \rightarrow D^0 \overline{D}^0 \gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+ e^- \rightarrow D^0 \overline{D}^0$
seen	PAKHLOVA	08	BELL	$e^+ e^- \rightarrow D^0 \overline{D}^0 \gamma$

$\Gamma(D^+ D^-)/\Gamma_{total}$ — Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+ e^- \rightarrow D^+ D^- \gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+ e^- \rightarrow D^+ D^-$
seen	PAKHLOVA	08	BELL	$e^+ e^- \rightarrow D^+ D^- \gamma$

$\Gamma(D \overline{D})/\Gamma(D^* \overline{D} + \text{c.c.})$ — Γ_2/Γ_5

VALUE	DOCUMENT ID		TECN	COMMENT
0.24±0.05±0.12	AUBERT	09M	BABR	$e^+ e^- \rightarrow \gamma D^{(*)} \overline{D}$

$\Gamma(D^0 \overline{D}^0)/\Gamma(D^*(2007)^0 \overline{D}^0 + \text{c.c.})$ — Γ_3/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
0.05±0.03	[15] GOLDHABER	77	MRK1	$e^+ e^-$

[15] Phase-space factor (p^3) explicitly removed.

$\Gamma(D^*(2007)^0 \overline{D}^0 + \text{c.c.})/\Gamma_{total}$ — Γ_6/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+ e^- \rightarrow D^{*0} \overline{D}^0 \gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+ e^- \rightarrow D^{*0} \overline{D}^0$

$\Gamma(D^*(2010)^+ D^- + \text{c.c.})/\Gamma_{total}$ — Γ_7/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+ e^- \rightarrow D^{*+} D^- \gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+ e^- \rightarrow D^{*+} D^-$
seen	PAKHLOVA	07	BELL	$e^+ e^- \rightarrow D^{*+} D^- \gamma$

$\Gamma(D^*(2010)^+ D^- + \text{c.c.})/\Gamma(D^*(2007)^0 \overline{D}^0 + \text{c.c.})$ — Γ_7/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
0.95±0.09±0.10	AUBERT	09M	BABR	$e^+ e^- \rightarrow \gamma D^* \overline{D}$

$\Gamma(D^* \overline{D}^*)/\Gamma(D^* \overline{D} + \text{c.c.})$ — Γ_8/Γ_5

VALUE	DOCUMENT ID		TECN	COMMENT
0.18±0.14±0.03	AUBERT	09M	BABR	$e^+ e^- \rightarrow \gamma D^{(*)} \overline{D}^{(*)}$

$\Gamma(D^*(2007)^0 \overline{D}^*(2007)^0)/\Gamma_{total}$ — Γ_9/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+ e^- \rightarrow D^{*0} \overline{D}^{*0} \gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+ e^- \rightarrow D^{*0} \overline{D}^{*0}$

$\Gamma(D^*(2007)^0 \overline{D}^*(2007)^0)/\Gamma(D^*(2007)^0 \overline{D}^0 + \text{c.c.})$ — Γ_9/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
32.0±12.0	[16] GOLDHABER	77	MRK1	$e^+ e^-$

[16] Phase-space factor (p^3) explicitly removed.

$\Gamma(D^*(2010)^+ D^*(2010)^-)/\Gamma_{total}$ — Γ_{10}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	AUBERT	09M	BABR	$e^+e^- \to D^{*+}D^{*-}\gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+e^- \to D^{*+}D^{*-}$
seen	PAKHLOVA	07	BELL	$e^+e^- \to D^{*+}D^{*-}\gamma$

$\Gamma(D^0 D^- \pi^+ + \text{c.c. (excl. } D^*(2007)^0 \overline{D}^0 + \text{c.c.}, D^*(2010)^+ D^- + \text{c.c.}))/\Gamma_{total}$ — Γ_{12}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	PAKHLOVA	08A	BELL	$e^+e^- \to D^0 D^- \pi^+\gamma$

$\Gamma(D\overline{D}^*\pi \text{ (excl. } D^*\overline{D}^*))/\Gamma_{total}$ — Γ_{13}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
not seen	CRONIN-HEN..	09	CLEO	$e^+e^- \to D\overline{D}^*\pi$

$\Gamma(D^0 \overline{D}^{*-} \pi^+ + \text{c.c. (excl. } D^*(2010)^+ D^*(2010)^-))/\Gamma_{total}$ — Γ_{14}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	PAKHLOVA	09	BELL	$e^+e^- \to D^0 D^{*-}\pi^+\gamma$

$\Gamma(D_s^+ D_s^-)/\Gamma_{total}$ — Γ_{15}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
seen	PAKHLOVA	11	BELL	$e^+e^- \to D_s^+ D_s^-\gamma$
seen	DEL-AMO-SA..	10N	BABR	$e^+e^- \to D_s^+ D_s^-\gamma$
seen	CRONIN-HEN..	09	CLEO	$e^+e^- \to D_s^+ D_s^-$

$\Gamma(J/\psi\pi^+\pi^-)/\Gamma_{total}$ — Γ_{17}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<4	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(J/\psi\pi^0\pi^0)/\Gamma_{total}$ — Γ_{18}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<2	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(J/\psi\eta)/\Gamma_{total}$ — Γ_{19}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
5.2±0.5±0.5		[17] ABLIKIM	12K	BES3	$e^+e^- \to \ell^+\ell^- 2\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<7	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

[17] ABLIKIM 12K measure $\sigma(e^+e^- \to J/\psi\eta) = 32.1 \pm 2.8 \pm 1.3$ pb. They assume the $\eta J/\psi$ fully originates from $\psi(4040)$ decays.

$\Gamma(J/\psi\pi^0)/\Gamma_{total}$ — Γ_{20}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<0.28	90	[18] ABLIKIM	12K	BES3	$e^+e^- \to \ell^+\ell^- 2\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

[18] ABLIKIM 12K measure $\sigma(e^+e^- \to J/\psi\pi^0) < 1.6$ pb. They assume the $\eta J/\psi$ fully originates from $\psi(4040)$ decays.

$\Gamma(J/\psi\pi^+\pi^-\pi^0)/\Gamma_{total}$ — Γ_{21}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<2	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\chi_{c1}\gamma)/\Gamma_{total}$ — Γ_{22}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<11	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\chi_{c2}\gamma)/\Gamma_{total}$ — Γ_{23}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<17	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\chi_{c1}\pi^+\pi^-\pi^0)/\Gamma_{total}$ — Γ_{24}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<11	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\chi_{c2}\pi^+\pi^-\pi^0)/\Gamma_{total}$ — Γ_{25}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<32	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(h_c(1P)\pi^+\pi^-)/\Gamma_{total}$ — Γ_{26}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<3	90	[19] PEDLAR	11	CLEO	$e^+e^- \to h_c(1P)\pi^+\pi^-$

[19] From several values of $\sqrt{s}$ near the peak of the $\psi(4040)$, PEDLAR 11 measures $\sigma(e^+e^- \to h_c(1P)\pi^+\pi^-) = 1.0 \pm 8.0 \pm 5.4 \pm 0.2$ pb, where the errors are statistical, systematic, and due to uncertainty in B($\psi(2S) \to \pi^0 h_c(1P)$), respectively.

$\Gamma(\phi\pi^+\pi^-)/\Gamma_{total}$ — Γ_{27}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<3	90	COAN	06	CLEO	3.97–4.06 $e^+e^- \to$ hadrons

$\Gamma(\Lambda\overline{\Lambda}\pi^+\pi^-)/\Gamma_{total}$ — Γ_{28}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<2.9	90	[20] ABLIKIM	13Q	BES3	$e^+e^- \to \psi(4040)$

[20] Assuming that interference effects between resonance and continuum can be neglected.

$\Gamma(\Lambda\overline{\Lambda}\pi^0)/\Gamma_{total}$ — Γ_{29}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<0.9	90	[21] ABLIKIM	13Q	BES3	$e^+e^- \to \psi(4040)$

[21] Assuming that interference effects between resonance and continuum can be neglected.

$\Gamma(\Lambda\overline{\Lambda}\eta)/\Gamma_{total}$ — Γ_{30}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<3.0	90	[22] ABLIKIM	13Q	BES3	$e^+e^- \to \psi(4040)$

[22] Assuming that interference effects between resonance and continuum can be neglected.

$\Gamma(\Sigma^+\overline{\Sigma}^-)/\Gamma_{total}$ — Γ_{31}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<1.3	90	[23] ABLIKIM	13Q	BES3	$e^+e^- \to \psi(4040)$

[23] Assuming that interference effects between resonance and continuum can be neglected.

$\Gamma(\Sigma^0\overline{\Sigma}^0)/\Gamma_{total}$ — Γ_{32}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<0.7	90	[24] ABLIKIM	13Q	BES3	$e^+e^- \to \psi(4040)$

[24] Assuming that interference effects between resonance and continuum can be neglected.

$\Gamma(\Xi^+\overline{\Xi}^-)/\Gamma_{total}$ — Γ_{33}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<1.6	90	[25] ABLIKIM	13Q	BES3	$e^+e^- \to \psi(4040)$

[25] Assuming that interference effects between resonance and continuum can be neglected.

$\Gamma(\Xi^0\overline{\Xi}^0)/\Gamma_{total}$ — Γ_{34}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<1.8	90	[26] ABLIKIM	13Q	BES3	$e^+e^- \to \psi(4040)$

[26] Assuming that interference effects between resonance and continuum can be neglected.

ψ(4040) REFERENCES

ABLIKIM	13Q	PR D87 112011	Ablikim M. et al.	(BES III Collab.)
WANG	13B	PR D87 051101	X.L. Wang et al.	(BELLE Collab.)
ABLIKIM	12K	PR D86 071101	M. Ablikim et al.	(BES III Collab.)
PAKHLOVA	11	PR D83 011101	G. Pakhlova et al.	(BELLE Collab.)
PEDLAR	11	PRL 107 041803	T. Pedlar et al.	(CLEO Collab.)
DEL-AMO-SA...	10N	PR D82 052004	P. del Amo Sanchez et al.	(BABAR Collab.)
MO	10	PR D82 077501	X.H. Mo, C.Z. Yuan, P. Wang	(BHEP)
AUBERT	09M	PR D79 092001	B. Aubert et al.	(BABAR Collab.)
CRONIN-HEN...	09	PR D80 072001	D. Cronin-Hennessy et al.	(CLEO Collab.)
PAKHLOVA	09	PR D80 091101	G. Pakhlova et al.	(BELLE Collab.)
ABLIKIM	08D	PL B660 315	M. Ablikim et al.	(BES Collab.)
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BAI	02C	PRL 88 101802	J.Z. Bai et al.	(BES Collab.)
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