$f_J(1710)$

$I^G(J^{PC}) = 0^+(\text{even}^{++})$

THE $f_J(1710)$

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The $f_J(1710)$ is seen in the radiative decay $J/\psi(1S) \to \gamma f_J(1710)$; therefore $C = +1$. It decays into 2η and $K^0_S K^0_S$, which implies $I^G J^{PC} = 0^+(\text{even})^{++}$. The spin of the $f_J(1710)$ is controversial. Combined amplitude analyses of the K^+K^-, $K_S K_S$ and $\pi^+\pi^-$ systems produced in $J/\psi(1S)$ radiative decay (in recent and some earlier unpublished analyses by the Mark III Collaboration) find a large spin-0 component, as well as reproducing known parameters of the $f_2(1270)$ and $f_2'(1525)$. A recent reanalysis (BUGG 95) of the 4π channel from MARK III, allowing both $\rho\rho$ and two $\pi\pi$ S waves, finds two states, a 0^{++} at $\sim$ 1750 MeV and a 2^{++} at $\sim$ 1620 MeV. Earlier analyses of the $\rho\rho$ final state (BISELLO 89B, BALTRUSAITIS 86B) found only pseudoscalar activity in the $f_J(1710)$ region, but considered only the process $J/\psi(1S) \to \gamma\rho\rho$. In contrast, a spin 2 was found for the $f_J(1710)$ in earlier analyses of the $\eta\eta$ (BLOOM 83) or K^+K^- (BALTRUSAITIS 87) systems based on less statistics. More recently, an analysis of the K^+K^- channel finds indications for a lower mass tensor as well as a higher mass scalar state (BAI 96C).

In pp central production at 300 GeV/c in both K^+K^- and $K^0_S K^0_S$, $f_J(1710)$ is definitely spin 2 (ARMSTRONG 89D). More recent analyses with greater statistics (E690 Collaboration, unpublished) are, however, not able to differentiate between spin 0 and 2. Generally, analyses preferring spin 2 concentrate on angular distributions in the $f_J(1710)$ region, and do not include possible interferences or distortion due to the nearby $f_2'(1525)$.

The $f_J(1710)$ is also observed in $K\overline{K}$ (FALVARD 88) in $J/\psi(1S) \rightarrow \omega K\overline{K}$ and $J/\psi(1S) \rightarrow \phi K\overline{K}$, but with no spin-parity analysis. ARMSTRONG 93C also sees a broad peak at 1747 MeV in $p\overline{p}$ annihilation into $\eta\eta$, which may be the $f_J(1710)$. This resonance is not observed in the hypercharge-exchange reactions $K^- p \rightarrow K^0_S K^0_S \Lambda$ (ASTON 88D) and $K^- p \rightarrow K^0_S K^0_S Y^*$ (BOLONKIN 86).

A partial-wave analysis of the $K^0_S K^0_S$ system in $\pi^- p \rightarrow K^0_S K^0_S n$ (BOLONKIN 88) finds a D_0-wave behavior ($J^{PC} = 2^{++}$) near 1700 MeV, but the width ($\sim$ 30 MeV) is much smaller than those observed in $J/\psi(1S)$ decays and in hadroproduction. The 0^{++} wave shows, however a broad enhancement around 1720 MeV.

$f_J(1710)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
1712± 5 OUR AVERAGE	Error includes scale factor of 1.1.			
1713±10	[1] ARMSTRONG	89D	OMEG	300 $pp \rightarrow ppK^+K^-$
1706±10	[1] ARMSTRONG	89D	OMEG	300 $pp \rightarrow ppK^0_S K^0_S$
1707±10	[2] AUGUSTIN	88	DM2	$J/\psi \rightarrow \gamma K^+K^-$, $K^0_S K^0_S$
1698±15	[2] AUGUSTIN	87	DM2	$J/\psi \rightarrow \gamma \pi^+\pi^-$
1720±10±10	[3] BALTRUSAIT...	87	MRK3	$J/\psi \rightarrow \gamma K^+K^-$
1742±15	[2] WILLIAMS	84	MPSF	200 $\pi^- N \rightarrow 2K^0_S X$
1670±50	BLOOM	83	CBAL	$J/\psi \rightarrow \gamma 2\eta$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1704^{+16}_{-23}	[4] DUNWOODIE	97		$J/\psi \rightarrow K\overline{K}, \pi\pi$
1690±11	[5] ABREU	96C	DLPH	$\gamma\gamma \rightarrow K^+K^-$ E^{ee}_{cm}= 91.2 GeV
$1696\pm 5^{+9}_{-34}$	[3] BAI	96C	BES	$J/\psi \rightarrow \gamma K^+K^-$
$1781\pm 8^{+10}_{-31}$	[6] BAI	96C	BES	$J/\psi \rightarrow \gamma K^+K^-$
1768±14	BALOSHIN	95	SPEC	40 π^- C $\rightarrow K^0_S K^0_S X$
1750±15	[7] BUGG	95	MRK3	$J/\psi \rightarrow \gamma\pi^+\pi^-\pi^+\pi^-$
1620±16	[3] BUGG	95	MRK3	$J/\psi \rightarrow \gamma\pi^+\pi^-\pi^+\pi^-$
1748±10	[2] ARMSTRONG	93C	E760	$\overline{p}p \rightarrow \pi^0\eta\eta \rightarrow 6\gamma$
~ 1750	BREAKSTONE	93	SFM	$pp \rightarrow pp\pi^+\pi^-\pi^+\pi^-$

1744±15	[8] ALDE	92D	GAM2	38 $\pi^- p \to \eta\eta N^*$
1700±15	[3] BOLONKIN	88	SPEC	40 $\pi^- p \to K^0_S K^0_S n$
1720±60	[6] BOLONKIN	88	SPEC	40 $\pi^- p \to K^0_S K^0_S n$
1638±10	[9] FALVARD	88	DM2	$J/\psi \to \phi K^+ K^-$, $K^0_S K^0_S$
1690± 4	[10] FALVARD	88	DM2	$J/\psi \to \phi K^+ K^-$, $K^0_S K^0_S$
$1730^{+\ 2}_{-10}$	[11] LONGACRE	86	RVUE	22 $\pi^- p \to n 2K^0_S$
1650±50	BURKE	82	MRK2	$J/\psi \to \gamma 2\rho$
1640±50	[12,13] EDWARDS	82D	CBAL	$J/\psi \to \gamma 2\eta$
1730±10±20	[14] ETKIN	82C	MPS	23 $\pi^- p \to n 2K^0_S$

[1] $J^P = 2^+$, (0^+ excluded).
[2] No J^{PC} determination.
[3] $J^P = 2^+$.
[4] $J^P = 0^+$, reanalysis of MARK III data.
[5] No J^{PC} determination, width not determined.
[6] $J^P = 0^+$.
[7] From a fit to the 0^+ partial wave.
[8] ALDE 92D combines all the GAMS-2000 data.
[9] From an analysis ignoring interference with $f'_2(1525)$.
[10] From an analysis including interference with $f'_2(1525)$.
[11] Uses MRK3 data. From a partial-wave analysis of data using a K-matrix formalism with 5 poles, but assuming spin 2. Fit with constrained inelasticity.
[12] $J^P = 2^+$ preferred.
[13] From fit neglecting nearby $f'_2(1525)$. Replaced by BLOOM 83.
[14] Superseded by LONGACRE 86.

$f_J(1710)$ WIDTH

VALUE (MeV)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
133 ± 14 OUR AVERAGE		Error includes scale factor of 1.2.		
181 ± 30		[15] ARMSTRONG	89D OMEG	300 $pp \to ppK^+K^-$
104 ± 30		[15] ARMSTRONG	89D OMEG	300 $pp \to ppK^0_S K^0_S$
166.4± 33.2		[16] AUGUSTIN	88 DM2	$J/\psi \to \gamma K^+ K^-$, $K^0_S K^0_S$
136 ± 28		[16] AUGUSTIN	87 DM2	$J/\psi \to \gamma \pi^+ \pi^-$
130 ± 20		[17] BALTRUSAIT...	87 MRK3	$J/\psi \to \gamma K^+ K^-$
57 ± 38		[2] WILLIAMS	84 MPSF	200 $\pi^- N \to 2K^0_S X$
160 ± 80		BLOOM	83 CBAL	$J/\psi \to \gamma 2\eta$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$124\ {}^{+\ 52}_{-\ 44}$		[18] DUNWOODIE	97	$J/\psi \to K\overline{K}, \pi\pi$
$103 \pm 18\ {}^{+30}_{-11}$		[17] BAI	96C BES	$J/\psi \to \gamma K^+ K^-$
$85 \pm 24\ {}^{+22}_{-19}$		[19] BAI	96C BES	$J/\psi \to \gamma K^+ K^-$
56 ± 19		BALOSHIN	95 SPEC	40 $\pi^- C \to K^0_S K^0_S X$
160 ± 40		[20] BUGG	95 MRK3	$J/\psi \to \gamma \pi^+ \pi^- \pi^+ \pi^-$

160^{+60}_{-20}		[17]	BUGG	95	MRK3	$J/\psi \to \gamma\pi^+\pi^-\pi^+\pi^-$
264 ± 25		[16]	ARMSTRONG	93C	E760	$\overline{p}p \to \pi^0\eta\eta \to 6\gamma$
200 to 300			BREAKSTONE	93	SFM	$pp \to pp\pi^+\pi^-\pi^+\pi^-$
< 80	90	[21]	ALDE	92D	GAM2	$38\ \pi^- p \to \eta\eta N^*$
30 ± 20		[17]	BOLONKIN	88	SPEC	$40\ \pi^- p \to K^0_S K^0_S n$
350 ± 150		[19]	BOLONKIN	88	SPEC	$40\ \pi^- p \to K^0_S K^0_S n$
148 ± 17		[22]	FALVARD	88	DM2	$J/\psi \to \phi K^+K^-, K^0_S K^0_S$
184 ± 6		[23]	FALVARD	88	DM2	$J/\psi \to \phi K^+K^-, K^0_S K^0_S$
122^{+74}_{-15}		[24]	LONGACRE	86	RVUE	$22\ \pi^- p \to n2K^0_S$
200 ± 100			BURKE	82	MRK2	$J/\psi \to \gamma 2\rho$
220^{+100}_{-70}		[25,26]	EDWARDS	82D	CBAL	$J/\psi \to \gamma 2\eta$
$200.0^{+156.0}_{-9.0}$		[27]	ETKIN	82B	MPS	$23\ \pi^- p \to n2K^0_S$

[15] $J^P = 2^+$, (0^+ excluded).
[16] No J^{PC} determination.
[17] $J^P = 2^+$.
[18] $J^P = 0^+$, reanalysis of MARK III data.
[19] $J^P = 0^+$.
[20] From a fit to the 0^+ partial wave.
[21] ALDE 92D combines all the GAMS-2000 data.
[22] From an analysis ignoring interference with $f'_2(1525)$.
[23] From an analysis including interference with $f'_2(1525)$.
[24] Uses MRK3 data. From a partial-wave analysis of data using a K-matrix formalism with 5 poles, but assuming spin 2. Fit with constrained inelasticity.
[25] $J^P = 2^+$ preferred.
[26] From fit neglecting nearby $f'_2(1525)$. Replaced by BLOOM 83.
[27] From an amplitude analysis of the $K^0_S K^0_S$ system, superseded by LONGACRE 86.

$f_J(1710)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$K\overline{K}$	seen
Γ_2	$\eta\eta$	seen
Γ_3	$\pi\pi$	seen
Γ_4	$\rho\rho$	
Γ_5	$\gamma\gamma$	

$f_J(1710)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(K\overline{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_1\Gamma_5/\Gamma$

VALUE (keV)	CL%	DOCUMENT ID		TECN	COMMENT
<0.11	95	[28] BEHREND	89C	CELL	$\gamma\gamma \rightarrow K^0_S K^0_S$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.48	95	ALBRECHT	90G	ARG	$\gamma\gamma \rightarrow K^+ K^-$
<0.28	95	[28] ALTHOFF	85B	TASS	$\gamma\gamma \rightarrow K\overline{K}\pi$

[28] Assuming helicity 2.

$f_J(1710)$ BRANCHING RATIOS

$\Gamma(K\overline{K})/\Gamma_{\text{total}}$ — Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$0.38^{+0.09}_{-0.19}$	[29,30] LONGACRE	86	MPS	$22\ \pi^- p \rightarrow n 2K^0_S$

$\Gamma(\eta\eta)/\Gamma_{\text{total}}$ — Γ_2/Γ

VALUE	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.18^{+0.03}_{-0.13}$	[29,30] LONGACRE	86	RVUE

$\Gamma(\pi\pi)/\Gamma_{\text{total}}$ — Γ_3/Γ

VALUE	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.039^{+0.002}_{-0.024}$	[29,30] LONGACRE	86	RVUE

$\Gamma(\pi\pi)/\Gamma(K\overline{K})$ — Γ_3/Γ_1

VALUE	DOCUMENT ID		TECN	COMMENT
0.39±0.14	ARMSTRONG	91	OMEG	$300\ pp \rightarrow pp\pi\pi,\ ppK\overline{K}$

$\Gamma(\eta\eta)/\Gamma(K\overline{K})$ — Γ_2/Γ_1

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.02	90	[31] PROKOSHKIN	91	GA24	$300\ \pi^- p \rightarrow \pi^- p\eta\eta$

[29] From a partial-wave analysis of data using a K-matrix formalism with 5 poles, but assuming spin 2.

[30] Fit with constrained inelasticity.

[31] Combining results of GAM4 with those of ARMSTRONG 89D.

$f_J(1710)$ REFERENCES

DUNWOODIE	97	Hadron 97 Conf.	W. Dunwoodie	(SLAC)
ABREU	96C	PL B379 309	+Adam, Adye+	(DELPHI Collab.)
BAI	96C	PRL 77 3959	J.Z. Bai+	(BES Collab.)
BALOSHIN	95	PAN 58 46	+Bolonkin, Vladimirskii+	(ITEP)
		Translated from YAF 58 50.		
BUGG	95	PL B353 378	+Scott, Zoli+	(LOQM, PNPI, WASH)
ARMSTRONG	93C	PL B307 394	+Bettoni+	(FNAL, FERR, GENO, UCI, NWES+)
BREAKSTONE	93	ZPHY C58 251	+Campanini+	(IOWA, CERN, DORT, HEIDH, WARS)
ALDE	92D	PL B284 457	+Binon, Bricman+	(GAM2 Collab.)
Also	91	SJNP 54 451	Alde, Binon, Bricman+	(GAM2 Collab.)
		Translated from YAF 54 745.		
ARMSTRONG	91	ZPHY C51 351	+Benayoun+	(ATHU, BARI, BIRM, CERN, CDEF)
PROKOSHKIN	91	SPD 36 155		(GAM2, GAM4 Collab.)
		Translated from DANS 316 900.		
ALBRECHT	90G	ZPHY C48 183	+Ehrlichmann, Harder+	(ARGUS Collab.)
ARMSTRONG	89D	PL B227 186	+Benayoun	(ATHU, BARI, BIRM, CERN, CDEF)
BEHREND	89C	ZPHY C43 91	+Criegee, Dainton+	(CELLO Collab.)
AUGUSTIN	88	PRL 60 2238	+Calcaterra+	(DM2 Collab.)
BOLONKIN	88	NP B309 426	+Bloshenko, Gorin+	(ITEP, SERP)
FALVARD	88	PR D38 2706	+Ajaltouni+	(CLER, FRAS, LALO, PADO)
AUGUSTIN	87	ZPHY C36 369	+Cosme+	(LALO, CLER, FRAS, PADO)
BALTRUSAIT...	87	PR D35 2077	Baltrusaitis, Coffman, Dubois+	(Mark III Collab.)
LONGACRE	86	PL B177 223	+Etkin+	(BNL, BRAN, CUNY, DUKE, NDAM)
ALTHOFF	85B	ZPHY C29 189	+Braunschweig, Kirschfink+	(TASSO Collab.)
WILLIAMS	84	PR D30 877	+Diamond+	(VAND, NDAM, TUFTS, ARIZ, FNAL+)
BLOOM	83	ARNS 33 143	+Peck	(SLAC, CIT)
BURKE	82	PRL 49 632	+Trilling, Abrams, Alam, Blocker+	(LBL, SLAC)
EDWARDS	82D	PRL 48 458	+Partridge, Peck+	(CIT, HARV, PRIN, STAN, SLAC)
ETKIN	82B	PR D25 1786	+Foley, Lai+	(BNL, CUNY, TUFTS, VAND)
ETKIN	82C	PR D25 2446	+Foley, Lai+	(BNL, CUNY, TUFTS, VAND)

OTHER RELATED PAPERS

ANISOVICH	97	PL B395 123	+Sarantsev	(PNPI)
BISELLO	89B	PR D39 701	Busetto+	(DM2 Collab.)
ASTON	88D	NP B301 525	+Awaji, Bienz+	(SLAC, NAGO, CINC, INUS)
AKESSON	86	NP B264 154	+Albrow, Almehed+	(Axial Field Spec. Collab.)
ARMSTRONG	86B	PL 167B 133	+Bloodworth, Carney+	(ATHU, BARI, BIRM, CERN)
BALTRUSAIT...	86B	PR D33 1222	Baltrusaitis, Coffman, Hauser+	(Mark III Collab.)
ALTHOFF	83	PL 121B 216	+Brandelik, Boerner, Burkhardt+	(TASSO Collab.)
BARNETT	83B	PL 120B 455	+Blockus, Burka, Chien, Christian+	(JHU)
ALTHOFF	82	ZPHY C16 13	+Boerner, Burkhardt+	(TASSO Collab.)
BARNES	82	PL B116 365	+Close	(RHEL)
BARNES	82B	NP B198 360	+Close, Monaghan	(RHEL, OXFTP)
TANIMOTO	82	PL 116B 198		(BIEL)