$f_0(1710)$

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

THE $f_0(1710)$

Updated April 2002 by M. Doser (CERN).

The $f_0(1710)$ is seen in the radiative decay $J/\psi(1S) \to \gamma f_0(1710)$; therefore $C = +1$. It decays into 2η and $K^0_S K^0_S$, which implies $I^G J^{PC} = 0^+(even)^{++}$. The spin of the $f_0(1710)$ has been controversial, but evidence for spin 0 has accumulated recently in all production modes.

An analysis of radiative $J/\psi(1S)$ decays at BES into $\pi^+\pi^-\pi^+\pi^-$ (BAI 00) clearly favors spin 0. Combined amplitude analyses of the K^+K^-, $K_S K_S$, and $\pi^+\pi^-$ systems produced in $J/\psi(1S)$ radiative decay by MARK III (CHEN 91 and more recently DUNWOODIE 97) find a large spin-0 component, as well as reproducing known parameters of the $f_2(1270)$ and $f'_2(1525)$. In addition, a recent reanalysis (BUGG 95) of the 4π channel from MARK III, allowing both $\rho\rho$ and two $\pi\pi$ S waves, also finds a 0^{++} assignment for the $f_0(1710)$. Earlier analyses of this final state (BISELLO 89B, BALTRUSAITIS 86B) found only pseudoscalar activity in the $f_0(1710)$ region, but considered only the process $J/\psi(1S) \to \gamma\rho\rho$. Similarly, earlier analyses of the K^+K^- system based on less statistics (BALTRUSAITIS 87, BAI 96) found a spin of 2 for the $f_0(1710)$.

A similar situation is present in central production, with earlier analyses favoring spin 2 over spin 0 (ARMSTRONG 89D). More recent analyses with greater statistics [BARBERIS 99 (K^+K^-,$K_S K_S$), BARBERIS 99B ($\pi^+\pi^-$), and FRENCH 99 (K^+K^-)], however, clearly indicate spin 0, and exclude spin 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 $f_0(1710)$ 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, as well as in $\eta\eta$ in radiative $J/\psi(1S)$ decays (EDWARDS 82). It is also clearly seen in 300-GeV/c pp central production in both K^+K^- and $K_S^0K_S^0$ (ARMSTRONG 89D). Mass and width are determined via a fit to non-interfering Breit-Wigners over a polynomial background, which leads to large systematic errors for the width. ARMSTRONG 93C also sees a broad peak in $\eta\eta$ at 1747 MeV, which may be the $f_0(1710)$.

This resonance is not observed in the hypercharge-exchange reactions $K^-p \rightarrow K_S^0K_S^0\Lambda$ (ASTON 88D) and $K^-p \rightarrow K_S^0K_S^0Y^*$ (BOLONKIN 86); these non-observations are explained by a spin of 0 (LINDENBAUM 92). It is not observed in $\overline{p}p$ interactions, neither via its $\pi\pi$ nor its $\eta\eta$ decay (AMSLER 02). A possible observation in $\gamma\gamma$ collisions leading to K_SK_S (BRACCINI 99, but no spin determination), and a non-observation in $\gamma\gamma \rightarrow \pi^+\pi^-$ (BARATE 00E), are consistent with a large $\overline{s}s$ component.

References

References may be found at the end of the $f_0(1710)$ Listing.

f_0(1710) MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1713± 6	**OUR AVERAGE**				
1740^{+30}_{-25}		[1] BAI	00A	BES	$J/\psi \rightarrow \gamma(\pi^+\pi^-\pi^+\pi^-)$
1698±18		[2] BARBERIS	00E		450 $pp \rightarrow p_f \eta\eta p_s$
1710±12 ±11		[3] BARBERIS	99D	OMEG	450 $pp \rightarrow K^+K^-, \pi^+\pi^-$
1710±25		[4] FRENCH	99		300 $pp \rightarrow p_f(K^+K^-)p_s$
1707±10		[5] AUGUSTIN	88	DM2	$J/\psi \rightarrow \gamma K^+K^-, K_S^0K_S^0$
1698±15		[5] AUGUSTIN	87	DM2	$J/\psi \rightarrow \gamma\pi^+\pi^-$
1720±10 ±10		[6] BALTRUSAIT...	87	MRK3	$J/\psi \rightarrow \gamma K^+K^-$
1742±15		[5] WILLIAMS	84	MPSF	200 $\pi^-N \rightarrow 2K_S^0X$
1670±50		BLOOM	83	CBAL	$J/\psi \rightarrow \gamma 2\eta$

• • • We do not use the following data for averages, fits, limits, etc. • • •

1767±14		221	[22] ACCIARRI	01H	L3	$\gamma\gamma \to K^0_S K^0_S$, E^{ee}_{cm}= 91, 183–209 GeV
1770±12			[7,8] ANISOVICH	99B	SPEC	0.6–1.2 $p\overline{p} \to \eta\eta\pi^0$
1730±15			[1] BARBERIS	99	OMEG	450 $pp \to p_s p_f K^+ K^-$
1750±20			[1] BARBERIS	99B	OMEG	450 $pp \to p_s p_f \pi^+\pi^-$
1750±30			[9] ANISOVICH	98B	RVUE	Compilation
1720±39			BAI	98H	BES	$J/\psi \to \gamma\pi^0\pi^0$
1775± 1.5		57	[10] BARKOV	98		$\pi^- p \to K^0_S K^0_S n$
1690±11			[11] ABREU	96C	DLPH	$Z^0 \to K^+ K^- + X$
1696± 5	$^{+9}_{-34}$		[6] BAI	96C	BES	$J/\psi \to \gamma K^+ K^-$
1781± 8	$^{+10}_{-31}$		[1] BAI	96C	BES	$J/\psi \to \gamma K^+ K^-$
1768±14			BALOSHIN	95	SPEC	40 π^- C $\to K^0_S K^0_S$X
1750±15			[12] BUGG	95	MRK3	$J/\psi \to \gamma\pi^+\pi^-\pi^+\pi^-$
1620±16			[6] BUGG	95	MRK3	$J/\psi \to \gamma\pi^+\pi^-\pi^+\pi^-$
1748±10			[5] ARMSTRONG	93C	E760	$\overline{p}p \to \pi^0\eta\eta \to 6\gamma$
∼ 1750			BREAKSTONE	93	SFM	$pp \to pp\pi^+\pi^-\pi^+\pi^-$
1744±15			[13] ALDE	92D	GAM2	38 $\pi^- p \to \eta\eta n$
1713±10			[14] ARMSTRONG	89D	OMEG	300 $pp \to ppK^+K^-$
1706±10			[14] ARMSTRONG	89D	OMEG	300 $pp \to ppK^0_S K^0_S$
1700±15			[6] BOLONKIN	88	SPEC	40 $\pi^- p \to K^0_S K^0_S n$
1720±60			[1] BOLONKIN	88	SPEC	40 $\pi^- p \to K^0_S K^0_S n$
1638±10			[15] FALVARD	88	DM2	$J/\psi \to \phi K^+ K^-$, $K^0_S K^0_S$
1690± 4			[16] FALVARD	88	DM2	$J/\psi \to \phi K^+ K^-$, $K^0_S K^0_S$
1755± 8			[17] ALDE	86C	GAM2	38 $\pi^- p \to n2\eta$
1730^{+2}_{-10}			[18] LONGACRE	86	RVUE	22 $\pi^- p \to n2K^0_S$
1650±50			BURKE	82	MRK2	$J/\psi \to \gamma 2\rho$
1640±50			[19,20] EDWARDS	82D	CBAL	$J/\psi \to \gamma 2\eta$
1730±10	±20		[21] ETKIN	82C	MPS	23 $\pi^- p \to n2K^0_S$

[1] $J^P = 0^+$.
[2] T-matrix pole.
[3] Supersedes BARBERIS 99 and BARBERIS 99B.
[4] $J^P = 0^+$, supersedes by ARMSTRONG 89D.
[5] No J^{PC} determination.
[6] $J^P = 2^+$.
[7] $J^P = 0^+$.
[8] Not seen by AMSLER 02.
[9] T-matrix pole, assuming $J^P = 0^+$
[10] No J^{PC} determination.
[11] No J^{PC} determination, width not determined.
[12] From a fit to the 0^+ partial wave.
[13] ALDE 92D combines all the GAMS-2000 data.
[14] $J^P = 2^+$, superseded by FRENCH 99.

[15] From an analysis ignoring interference with $f'_2(1525)$.
[16] From an analysis including interference with $f'_2(1525)$.
[17] Superseded by ALDE 92D.
[18] 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.
[19] $J^P = 2^+$ preferred.
[20] From fit neglecting nearby $f'_2(1525)$. Replaced by BLOOM 83.
[21] Superseded by LONGACRE 86.
[22] Spin 2 dominant, isospin not determined, could also be I=1.

f_0(1710) WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
125 ± 10 OUR AVERAGE					
$120\ ^{+50}_{-40}$			[23] BAI 00A	BES	$J/\psi \to \gamma(\pi^+\pi^-\pi^+\pi^-)$
120 ± 26			[24] BARBERIS 00E		450 $pp \to p_f \eta\eta p_s$
126 ± 16 ±18			[25] BARBERIS 99D	OMEG	450 $pp \to K^+K^-$, $\pi^+\pi^-$
105 ± 34			[26] FRENCH 99		300 $pp \to p_f(K^+K^-)p_s$
166.4± 33.2			[27] AUGUSTIN 88	DM2	$J/\psi \to \gamma K^+K^-$, $K^0_S K^0_S$
136 ± 28			[27] AUGUSTIN 87	DM2	$J/\psi \to \gamma\pi^+\pi^-$
130 ± 20			[28] BALTRUSAIT...87	MRK3	$J/\psi \to \gamma K^+K^-$
57 ± 38			[5] 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. • • •					
187 ± 60		221	[42] ACCIARRI 01H	L3	$\gamma\gamma \to K^0_S K^0_S$, E^{ee}_{cm}= 91, 183–209 GeV
220 ± 42			[29,30] ANISOVICH 99B	SPEC	0.6–1.2 $p\overline{p} \to \eta\eta\pi^0$
100 ± 25			[23] BARBERIS 99	OMEG	450 $pp \to p_s p_f K^+K^-$
160 ± 30			[23] BARBERIS 99B	OMEG	450 $pp \to p_s p_f \pi^+\pi^-$
250 ±140			[31] ANISOVICH 98B	RVUE	Compilation
30 ± 7		57	[32] BARKOV 98		$\pi^- p \to K^0_S K^0_S n$
103 ± 18 $^{+30}_{-11}$			[28] BAI 96C	BES	$J/\psi \to \gamma K^+K^-$
85 ± 24 $^{+22}_{-19}$			[23] 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			[33] BUGG 95	MRK3	$J/\psi \to \gamma\pi^+\pi^-\pi^+\pi^-$
$160\ ^{+60}_{-20}$			[28] BUGG 95	MRK3	$J/\psi \to \gamma\pi^+\pi^-\pi^+\pi^-$
264 ± 25			[27] ARMSTRONG 93C	E760	$\overline{p}p \to \pi^0\eta\eta \to 6\gamma$

200 to 300			BREAKSTONE	93	SFM	$p p \to p p \pi^+ \pi^- \pi^+ \pi^-$
$<$ 80	90	[34]	ALDE	92D	GAM2	38 $\pi^- p \to \eta \eta N^*$
181 $\pm$ 30		[35]	ARMSTRONG	89D	OMEG	300 $p p \to p p K^+ K^-$
104 $\pm$ 30		[35]	ARMSTRONG	89D	OMEG	300 $p p \to p p K^0_S K^0_S$
30 $\pm$ 20		[28]	BOLONKIN	88	SPEC	40 $\pi^- p \to K^0_S K^0_S n$
350 $\pm$150		[23]	BOLONKIN	88	SPEC	40 $\pi^- p \to K^0_S K^0_S n$
148 $\pm$ 17		[36]	FALVARD	88	DM2	$J/\psi \to \phi K^+ K^-, K^0_S K^0_S$
184 $\pm$ 6		[37]	FALVARD	88	DM2	$J/\psi \to \phi K^+ K^-, K^0_S K^0_S$
122 $^{+74}_{-15}$		[38]	LONGACRE	86	RVUE	22 $\pi^- p \to n 2K^0_S$
200 $\pm$100			BURKE	82	MRK2	$J/\psi \to \gamma 2\rho$
220 $^{+100}_{-70}$		[39,40]	EDWARDS	82D	CBAL	$J/\psi \to \gamma 2\eta$
200.0 $^{+156.0}_{-9.0}$		[41]	ETKIN	82B	MPS	23 $\pi^- p \to n 2K^0_S$

[23] $J^P = 0^+$.
[24] T-matrix pole.
[25] Supersedes BARBERIS 99 and BARBERIS 99B.
[26] $J^P = 0^+$, supersedes by ARMSTRONG 89D.
[27] No J^{PC} determination.
[28] $J^P = 2^+$.
[29] $J^P = 0^+$.
[30] Not seen by AMSLER 02.
[31] T-matrix pole, assuming $J^P = 0^+$
[32] No J^{PC} determination.
[33] From a fit to the 0^+ partial wave.
[34] ALDE 92D combines all the GAMS-2000 data.
[35] $J^P = 2^+$, (0^+ excluded).
[36] From an analysis ignoring interference with $f'_2(1525)$.
[37] From an analysis including interference with $f'_2(1525)$.
[38] 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.
[39] $J^P = 2^+$ preferred.
[40] From fit neglecting nearby $f'_2(1525)$. Replaced by BLOOM 83.
[41] From an amplitude analysis of the $K^0_S K^0_S$ system, superseded by LONGACRE 86.
[42] Spin 2 dominant, isospin not determined, could also be I=1.

$f_0(1710)$ 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	$\gamma \gamma$	

$f_0(1710)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(K\overline{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_1\Gamma_4/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
<110	95	[44] BEHREND	89C	CELL	$\gamma\gamma \to K^0_S K^0_S$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$49\pm11\pm13$		[45] ACCIARRI	01H	L3	$\gamma\gamma \to K^0_S K^0_S$, E^{ee}_{cm}= 91, 183–209 GeV
<480	95	ALBRECHT	90G	ARG	$\gamma\gamma \to K^+ K^-$
<280	95	[44] ALTHOFF	85B	TASS	$\gamma\gamma \to K\overline{K}\pi$

$\Gamma(\pi\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ — $\Gamma_3\Gamma_4/\Gamma$

VALUE (keV)	CL%	DOCUMENT ID		TECN	COMMENT
<0.82	95	[43] BARATE	00E	ALEP	$\gamma\gamma \to \pi^+\pi^-$

[43] Assuming spin 0.

[44] Assuming helicity 2.

[45] Spin 2 dominant, isospin not determined, could also be I=1.

$f_0(1710)$ 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. • • •				
$0.38^{+0.09}_{-0.19}$	[46,47] LONGACRE	86	MPS	$22\ \pi^- p \to n 2K^0_S$

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

VALUE	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.18^{+0.03}_{-0.13}$	[46,47] LONGACRE	86	RVUE

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

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
not seen	AMSLER	02	CBAR	$0.9\ \overline{p}p \to \pi^0\eta\eta$, $\pi^0\pi^0\pi^0$
$0.039^{+0.002}_{-0.024}$	[46,47] 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	$300\ pp \to pp\pi\pi$, $ppK\overline{K}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$0.2\ \pm0.024\pm0.036$	BARBERIS	99D	OMEG	$450\ pp \to K^+K^-$, $\pi^+\pi^-$

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
0.48±0.15		BARBERIS 00E		450 $p p \rightarrow p_f \eta\eta p_s$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.02	90	[48] PROKOSHKIN 91	GA24	300 $\pi^- p \rightarrow \pi^- p \eta\eta$

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

[47] Fit with constrained inelasticity.

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

$f_0(1710)$ REFERENCES

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ACCIARRI	01H	PL B501 173	M. Acciarri *et al.*	(L3 Collab.)
BAI	00A	PL B472 207	J.Z. Bai *et al.*	(BES Collab.)
BARATE	00E	PL B472 189	R. Barate *et al.*	(ALEPH Collab.)
BARBERIS	00E	PL B479 59	D. Barberis *et al.*	(WA 102 Collab.)
ANISOVICH	99B	PL B449 154	A.V. Anisovich *et al.*	
BARBERIS	99	PL B453 305	D. Barberis *et al.*	(Omega expt.)
BARBERIS	99B	PL B453 316	D. Barberis *et al.*	(Omega expt.)
BARBERIS	99D	PL B462 462	D. Barberis *et al.*	(Omega expt.)
FRENCH	99	PL B460 213	B. French *et al.*	(WA76 Collab.)
ANISOVICH	98B	UFN 41 419	V.V. Anisovich *et al.*	
BAI	98H	PRL 81 1179	J.Z. Bai *et al.*	(BES Collab.)
BARKOV	98	JEPTL 68 764	B.P. Barkov *et al.*	
ABREU	96C	PL B379 309	P. Abreu *et al.*	(DELPHI Collab.)
BAI	96C	PRL 77 3959	J.Z. Bai *et al.*	(BES Collab.)
BALOSHIN	95	PAN 58 46	O.N. Baloshin *et al.*	(ITEP)
		Translated from YAF 58 50.		
BUGG	95	PL B353 378	D.V. Bugg *et al.*	(LOQM, PNPI, WASH)
ARMSTRONG	93C	PL B307 394	T.A. Armstrong *et al.*	(FNAL, FERR, GENO+)
BREAKSTONE	93	ZPHY C58 251	A.M. Breakstone *et al.*	(IOWA, CERN, DORT+)
ALDE	92D	PL B284 457	D.M. Alde *et al.*	(GAM2 Collab.)
Also	91	SJNP 54 451	D.M. Alde *et al.*	(GAM2 Collab.)
		Translated from YAF 54 745.		
ARMSTRONG	91	ZPHY C51 351	T.A. Armstrong *et al.*	(ATHU, BARI, BIRM+)
PROKOSHKIN	91	SPD 36 155	Y.D. Prokoshkin	(GAM2, GAM4 Collab.)
		Translated from DANS 316 900.		
ALBRECHT	90G	ZPHY C48 183	H. Albrecht *et al.*	(ARGUS Collab.)
ARMSTRONG	89D	PL B227 186	T.A. Armstrong, M. Benayoun	(ATHU, BARI, BIRM+)
BEHREND	89C	ZPHY C43 91	H.J. Behrend *et al.*	(CELLO Collab.)
AUGUSTIN	88	PRL 60 2238	J.E. Augustin *et al.*	(DM2 Collab.)
BOLONKIN	88	NP B309 426	B.V. Bolonkin *et al.*	(ITEP, SERP)
FALVARD	88	PR D38 2706	A. Falvard *et al.*	(CLER, FRAS, LALO+)
AUGUSTIN	87	ZPHY C36 369	J.E. Augustin *et al.*	(LALO, CLER, FRAS+)
BALTRUSAIT...	87	PR D35 2077	R.M. Baltrusaitis *et al.*	(Mark III Collab.)
ALDE	86C	PL B182 105	D.M. Alde *et al.*	(SERP, BELG, LANL, LAPP)
LONGACRE	86	PL B177 223	R.S. Longacre *et al.*	(BNL, BRAN, CUNY+)
ALTHOFF	85B	ZPHY C29 189	M. Althoff *et al.*	(TASSO Collab.)
WILLIAMS	84	PR D30 877	E.G.H. Williams *et al.*	(VAND, NDAM, TUFTS+)
BLOOM	83	ARNS 33 143	E.D. Bloom, C. Peck	(SLAC, CIT)
BURKE	82	PRL 49 632	D.L. Burke *et al.*	(LBL, SLAC)
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BRACCINI	99	Hadron Spectroscopy 53	S. Braccini	
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GODFREY	99	RMP 71 1411	S. Godfrey, J. Napolitano	
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ALTHOFF	83	PL 121B 216	M. Althoff *et al.*	(TASSO Collab.)
BARNETT	83B	PL 120B 455	B. Barnett *et al.*	(JHU)
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BARNES	82	PL B116 365	T. Barnes, F.E. Close	(RHEL)
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TANIMOTO	82	PL 116B 198	M. Tanimoto	(BIEL)