$f_J(2220)$

$I^G(J^{PC}) = 0^+(2^{++}$ or $4^{++})$

OMITTED FROM SUMMARY TABLE
THE $f_J(2220)$

Updated April 2000 by M. Doser (CERN).

This state has been observed in $J/\psi(1S)$ radiative decay into $K\overline{K}$ (K^+K^- and $K^0_S K^0_S$ modes seen (BALTRUSAITIS 86D, BAI 96B)). An upper limit from DM2 for these modes (AUGUSTIN 88) is at the level at which observation is claimed. There are also indications for further decay modes ($\pi^+\pi^-$ and $\overline{p}p$ (BAI 96B) and $\pi^0\pi^0$ (BAI 98H)) in the same production process, although again at the level at which previous upper limits had been obtained (BALTRUSAITIS 86D). This was also seen in $\eta\eta$ (ALDE 86B), $K^0_S K^0_S$ (ASTON 88D), and K^+K^- (ALDE 88 F), albeit with very low statistics. Its J^{PC} is determined from the angular distributions of these observations.

It is not seen in Υ radiative decays (BARU 89), B inclusive decays (BEHRENDS 84), nor in $\gamma\gamma$ (GODANG 97, ALAM 98C), which is not surprising, since if it were a glueball, its two-photon width would be expected to be small. It is also not seen in formation in $\overline{p}p \to K^+K^-$ (BARDIN 87, SCULLI 87), in $\overline{p}p \to K_S K_S$ (BARNES 93, EVANGELISTA 97), $\overline{p}p \to \phi\phi$ (EVANGELISTA 98), nor in $\overline{p}p \to \pi^+\pi^-$ (HASAN 96). The upper limit in $\overline{p}p$ formation can be related to the claimed decay into $\overline{p}p$ to give a lower limit for the process $J/\psi \to \gamma f_J(2220)$ of $\sim 2.3 \times 10^{-3}$ (GODFREY 99). Such a signal should be visible in the inclusive photon spectrum (BLOOM 85). The limit also leads to the surprising conclusion that the reported two-body final states constitute only a small fraction of all decay modes of the $f_J(2220)$. Observation of further decay modes and confirmation of the $\overline{p}p$ decay would be very desirable.

$f_J(2220)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
2231.1± 3.5 OUR AVERAGE					
$2235 \pm 4 \pm 6$	74	BAI	96B	BES	$e^+ e^- \to J/\psi \to$ $\gamma \pi^+ \pi^-$
$2230 \, {}^{+6}_{-7} \pm 16$	46	BAI	96B	BES	$e^+ e^- \to J/\psi \to$ $\gamma K^+ K^-$
$2232 \, {}^{+8}_{-7} \pm 15$	23	BAI	96B	BES	$e^+ e^- \to J/\psi \to$ $\gamma K^0_S K^0_S$
$2235 \pm 4 \pm 5$	32	BAI	96B	BES	$e^+ e^- \to J/\psi \to \gamma p \overline{p}$
$2209 \, {}^{+17}_{-15} \pm 10$		ASTON	88F	LASS	$11 \, K^- p \to K^+ K^- \Lambda$
2230 ± 20		BOLONKIN	88	SPEC	$40 \, \pi^- p \to K^0_S K^0_S n$
2220 ± 10	41	[1] ALDE	86B	GA24	$38-100 \, \pi p \to n \eta \eta'$
$2230 \pm 6 \pm 14$	93	BALTRUSAIT...	86D	MRK3	$e^+ e^- \to \gamma K^+ K^-$
$2232 \pm 7 \pm 7$	23	BALTRUSAIT...	86D	MRK3	$e^+ e^- \to \gamma K^0_S K^0_S$

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

2246 ± 36		BAI	98H	BES	$J/\psi \to \gamma \pi^0 \pi^0$

[1] ALDE 86B uses data from both the GAMS-2000 and GAMS-4000 detectors.

$f_J(2220)$ WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{23 \, {}^{+8}_{-7} \, OUR \, AVERAGE}$						
$19 \, {}^{+13}_{-11} \pm 12$		74	BAI	96B	BES	$e^+ e^- \to J/\psi \to$ $\gamma \pi^+ \pi^-$
$20 \, {}^{+20}_{-15} \pm 17$		46	BAI	96B	BES	$e^+ e^- \to J/\psi \to$ $\gamma K^+ K^-$
$20 \, {}^{+25}_{-16} \pm 14$		23	BAI	96B	BES	$e^+ e^- \to J/\psi \to$ $\gamma K^0_S K^0_S$
$15 \, {}^{+12}_{-9} \pm 9$		32	BAI	96B	BES	$e^+ e^- \to J/\psi \to \gamma p \overline{p}$
$60 \, {}^{+107}_{-57}$			ASTON	88F	LASS	$11 \, K^- p \to K^+ K^- \Lambda$
80 ± 30			BOLONKIN	88	SPEC	$40 \, \pi^- p \to K^0_S K^0_S n$
$26 \, {}^{+20}_{-16} \pm 17$		93	BALTRUSAIT...	86D	MRK3	$e^+ e^- \to \gamma K^+ K^-$
$18 \, {}^{+23}_{-15} \pm 10$		23	BALTRUSAIT...	86D	MRK3	$e^+ e^- \to \gamma K^0_S K^0_S$

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

<80	90		ALDE	87C	GAM2	$38 \, \pi^- p \to \eta' \eta n$

$f_J(2220)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\pi\pi$	seen
Γ_2	$\pi^+\pi^-$	seen
Γ_3	$K\overline{K}$	seen
Γ_4	$p\overline{p}$	seen
Γ_5	$\gamma\gamma$	not seen
Γ_6	$\eta\eta'(958)$	seen
Γ_7	$\phi\phi$	not seen

$f_J(2220)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(K\overline{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\qquad\qquad \Gamma_3\Gamma_5/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
< 5.6	95	[2] GODANG 97	CLE2	$\gamma\gamma \to K^0_S K^0_S$

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

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
< 86	95	[2] ALBRECHT 90G	ARG	$\gamma\gamma \to K^+K^-$
<1000	95	[3] ALTHOFF 85B	TASS	$\gamma\gamma$, $K\overline{K}\pi$

[2] Assuming $J^P = 2^+$.
[3] True for $J^P = 0^+$ and $J^P = 2^+$.

$\Gamma(\pi\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\qquad\qquad \Gamma_1\Gamma_5/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
<2.5	95	ALAM 98C	CLE2	$\gamma\gamma \to \pi^+\pi^-$

$f_J(2220)$ $\Gamma(i)\Gamma(\overline{p}p)/\Gamma(\text{total})$

$\Gamma(p\overline{p}) \times \Gamma(\pi^+\pi^-)/\Gamma_{\text{total}}$ $\qquad\qquad \Gamma_4\Gamma_2/\Gamma$

VALUE (keV)	CL%	DOCUMENT ID	TECN	COMMENT
<3.9	99	[4] HASAN 96	SPEC	$\overline{p}p \to \pi^-\pi^+$

[4] Assuming $\Gamma = 15$ MeV and $J^P = 2^+$

$\Gamma(p\overline{p}) \times \Gamma(\phi\phi)/\Gamma_{\text{total}}$ $\qquad\qquad \Gamma_4\Gamma_7/\Gamma$

VALUE (keV)	CL%	DOCUMENT ID	TECN	COMMENT
<0.9	95	[5] EVANGELISTA 98	SPEC	1.1-2.0 $p\overline{p} \to \phi\phi$

[5] Assuming $J^P = 2^+$, M=2235 MeV and $\Gamma_{total} = 15$ MeV.

$f_J(2220)$ BRANCHING RATIOS

$\Gamma(p\overline{p})/\Gamma_{\text{total}}$ $\qquad\qquad \Gamma_4/\Gamma$

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT

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

<3.0	95	[6] EVANGELISTA 97	SPEC	$1.96\text{-}2.40\,\overline{p}\,p \to K_S^0 K_S^0$
<1.1	99.7	[7] BARNES 93	SPEC	$1.3\text{-}1.57\,\overline{p}\,p \to K_S^0 K_S^0$
<2.6	99.7	[7] BARDIN 87	CNTR	$1.3\text{-}1.5\,\overline{p}\,p \to K^+ K^-$
<3.6	99.7	[7] SCULLI 87	CNTR	$1.29\text{-}1.55\,\overline{p}\,p \to K^+ K^-$

[6] Assuming $\Gamma \sim 20$ MeV, $J^P = 2^+$ and $B(f_J(2220) \to K\overline{K}) = 100\%$.

[7] Assuming $\Gamma = 30\text{-}35$ MeV, $J^P = 2^+$ and $B(f_J(2220) \to K\overline{K}) = 100\%$.

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

VALUE	DOCUMENT ID		TECN	COMMENT
1.0±0.5	BAI	96B	BES	$e^+ e^- \to J/\psi \to$ $\gamma 2\pi, K\overline{K}$

$\Gamma(p\overline{p})/\Gamma(K\overline{K})$ Γ_4/Γ_3

VALUE	DOCUMENT ID		TECN	COMMENT
0.17±0.09	BAI	96B	BES	$e^+ e^- \to J/\psi \to$ $\gamma p\overline{p}, K\overline{K}$

$f_J(2220)$ REFERENCES

ALAM	98C	PRL 81 3328	M.S. Alam *et al.*	(CLEO Collab.)
BAI	98H	PRL 81 1179	J.Z. Bai *et al.*	(BES Collab.)
EVANGELISTA	98	PR D57 5370	C. Evangelista *et al.*	
EVANGELISTA	97	PR D56 3803	C. Evangelista *et al.*	(LEAR Collab.)
GODANG	97	PRL 79 3829	R. Godang *et al.*	(CLEO Collab.)
BAI	96B	PRL 76 3502	J.Z. Bai *et al.*	(BES Collab.)
HASAN	96	PL B388 376	A. Hasan, D.V. Bugg	(BRUN, LOQM)
BARNES	93	PL B309 469	P.D. Barnes, P. Birien, W.H. Breunlich	
ALBRECHT	90G	ZPHY C48 183	H. Albrecht *et al.*	(ARGUS Collab.)
ASTON	88F	PL B215 199	D. Aston *et al.*	(SLAC, NAGO, CINC, INUS) JP
BOLONKIN	88	NP B309 426	B.V. Bolonkin *et al.*	(ITEP, SERP)
ALDE	87C	SJNP 45 255	D. Alde *et al.*	
		Translated from YAF 45 405.		
BARDIN	87	PL B195 292	G. Bardin *et al.*	(SACL, FERR, CERN, PADO+)
SCULLI	87	PRL 58 1715	J. Sculli *et al.*	(NYU, BNL)
ALDE	86B	PL B177 120	D.M. Alde *et al.*	(SERP, BELG, LANL, LAPP)
BALTRUSAIT...	86D	PRL 56 107	R.M. Baltrusaitis	(CIT, UCSC, ILL, SLAC+)
ALTHOFF	85B	ZPHY C29 189	M. Althoff *et al.*	(TASSO Collab.)

──── OTHER RELATED PAPERS ────

ANISOVICH	99D	PL B452 180	A.V. Anisovich *et al.*	
Also	99F	NP A651 253	A.V. Anisovich *et al.*	
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GODFREY	99	RMP 71 1411	S. Godfrey, J. Napolitano	
PROKOSHKIN	99	PAN 62 356	Yu.D. Prokoshkin *et al.*	
		Translated from YAF 62 396.		
HUANG	96	PL B380 189	T. Huang *et al.*	(BHEP, BEIJ)
BARDIN	87	PL B195 292	G. Bardin *et al.*	(SACL, FERR, CERN, PADO+)
YAOUANC	85	ZPHY C28 309	A. Le Yaouanc *et al.*	(ORSAY, TOKY)
GODFREY	84	PL 141B 439	S. Godfrey, R. Kokoski, N. Isgur	(TNTO)
SHATZ	84	PL 138B 209	M.P. Shatz	(CIT)
WILLEY	84	PRL 52 585	R.S. Willey	(PITT)
EISENHAND...	75	NP B96 109	E. Eisenhandler *et al.*	(LOQM, LIVP, DARE+)