

$f_J(2220)$

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

OMITTED FROM SUMMARY TABLE

Needs confirmation. See our mini-review in the 2004 edition of this Review, PDG 04.

 $f_J(2220)$ MASS

| VALUE (MeV) | EVTS | DOCUMENT ID | TECN | COMMENT |
|--|------|------------------------------|----------|--|
| 2231.1 ± 3.5 OUR AVERAGE | | | | |
| 2235 ± 4 ± 6 | 74 | BAI | 96B BES | $e^+e^- \rightarrow J/\psi \rightarrow \gamma\pi^+\pi^-$ |
| 2230 $^{+6}_{-7}$ ± 16 | 46 | BAI | 96B BES | $e^+e^- \rightarrow J/\psi \rightarrow \gamma K^+K^-$ |
| 2232 $^{+8}_{-7}$ ± 15 | 23 | BAI | 96B BES | $e^+e^- \rightarrow J/\psi \rightarrow \gamma K_S^0 K_S^0$ |
| 2235 ± 4 ± 5 | 32 | BAI | 96B BES | $e^+e^- \rightarrow J/\psi \rightarrow \gamma p\bar{p}$ |
| 2209 $^{+17}_{-15}$ ± 10 | | ASTON | 88F LASS | 11 $K^-p \rightarrow K^+K^-\Lambda$ |
| 2230 ± 20 | | BOLONKIN | 88 SPEC | 40 $\pi^-p \rightarrow K_S^0 K_S^0 n$ |
| 2220 ± 10 | 41 | ¹ ALDE | 86B GA24 | 38–100 $\pi p \rightarrow n\eta\eta'$ |
| 2230 ± 6 ± 14 | 93 | BALTRUSAIT..86D | MRK3 | $e^+e^- \rightarrow \gamma K^+K^-$ |
| 2232 ± 7 ± 7 | 23 | BALTRUSAIT..86D | MRK3 | $e^+e^- \rightarrow \gamma K_S^0 K_S^0$ |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | | |
| 2223.9 ± 2.5 | | ² VLADIMIRSK...08 | SPEC | 40 $\pi^-p \rightarrow K_S^0 K_S^0 n + m\pi^0$ |
| 2246 ± 36 | | BAI | 98H BES | $J/\psi \rightarrow \gamma\pi^0\pi^0$ |
| ¹ ALDE 86B uses data from both the GAMS-2000 and GAMS-4000 detectors. | | | | |
| ² $J^{PC} = 2^{++}$. Systematic uncertainties not evaluated | | | | |

 $f_J(2220)$ WIDTH

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

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

8.6 ± 2.5 ¹VLADIMIRSK...08 SPEC 40 $\pi^- p \rightarrow K_S^0 K_S^0 n$
 $+ m\pi^0$
 <80 90 ALDE 87C GAM2 38 $\pi^- p \rightarrow \eta' \eta n$
¹ $J^{PC} = 2^{++}$. Systematic uncertainties not evaluated

$f_J(2220)$ DECAY MODES

| Mode | Fraction (Γ_i/Γ) |
|-----------------------------|--------------------------------|
| Γ_1 $\pi\pi$ | not seen |
| Γ_2 $\pi^+\pi^-$ | not seen |
| Γ_3 $K\bar{K}$ | not seen |
| Γ_4 $p\bar{p}$ | not seen |
| Γ_5 $\gamma\gamma$ | not seen |
| Γ_6 $\eta\eta'(958)$ | seen |
| Γ_7 $\phi\phi$ | not seen |
| Γ_8 $\eta\eta$ | not seen |

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

| $\Gamma(K\bar{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ | | | | $\Gamma_3\Gamma_5/\Gamma$ | |
|--|-----|------------------------------|------|---|--|
| VALUE (eV) | CL% | DOCUMENT ID | TECN | COMMENT | |
| < 1.4 | 95 | ¹ ACCIARRI 01H L3 | | $\gamma\gamma \rightarrow K_S^0 K_S^0, E_{\text{cm}}^{\text{ee}} = 91, 183\text{--}209 \text{ GeV}$ | |

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

| | | | | |
|-------|----|-------------------------------|--|--|
| < 5.6 | 95 | ¹ GODANG 97 CLE2 | | $\gamma\gamma \rightarrow K_S^0 K_S^0$ |
| < 86 | 95 | ¹ ALBRECHT 90G ARG | | $\gamma\gamma \rightarrow K^+ K^-$ |
| <1000 | 95 | ² ALTHOFF 85B TASS | | $\gamma\gamma, K\bar{K}\pi$ |

| $\Gamma(\pi\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ | | | | $\Gamma_1\Gamma_5/\Gamma$ | |
|--|-----|---------------|------|---------------------------------------|--|
| VALUE (eV) | CL% | DOCUMENT ID | TECN | COMMENT | |
| <2.5 | 95 | ALAM 98C CLE2 | | $\gamma\gamma \rightarrow \pi^+\pi^-$ | |

¹ Assuming $J^P = 2^+$.

² True for $J^P = 0^+$ and $J^P = 2^+$.

$f_J(2220) \Gamma(i)\Gamma(p\bar{p})/\Gamma^2(\text{total})$

| $\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\pi\pi)/\Gamma_{\text{total}}$ | | | | $\Gamma_4/\Gamma \times \Gamma_1/\Gamma$ | |
|--|-----|-----------------------------|------|---|--|
| VALUE (units 10^{-5}) | CL% | DOCUMENT ID | TECN | COMMENT | |
| <18 | 95 | ¹ AMSLER 01 CBAR | | $1.4\text{--}1.5 p\bar{p} \rightarrow \pi^0\pi^0$ | |

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

| | | | | |
|----------|----|----------------------------|--|---|
| <(11–42) | 99 | ² HASAN 96 SPEC | | $1.35\text{--}1.55 p\bar{p} \rightarrow \pi^+\pi^-$ |
|----------|----|----------------------------|--|---|

| $\Gamma(p\bar{p})/\Gamma_{\text{total}} \times \Gamma(\phi\phi)/\Gamma_{\text{total}}$ | | | | $\Gamma_4/\Gamma \times \Gamma_7/\Gamma$ | |
|--|-----|-----------------------------------|------|---|--|
| VALUE (units 10^{-5}) | CL% | DOCUMENT ID | TECN | COMMENT | |
| <6 | 95 | ³ EVANGELIS... 98 SPEC | | $1.1\text{--}2.0 p\bar{p} \rightarrow \phi\phi$ | |

$$\Gamma(\rho\bar{\rho})/\Gamma_{\text{total}} \times \Gamma(\eta\eta)/\Gamma_{\text{total}} \qquad \Gamma_4/\Gamma \times \Gamma_8/\Gamma$$

| VALUE (units 10^{-5}) | CL% | DOCUMENT ID | TECN | COMMENT |
|--------------------------|-----|------------------------|------|---|
| <4 | 95 | ¹ AMSLER 01 | CBAR | 1.4–1.5 $\rho\bar{\rho} \rightarrow \eta\eta$ |

¹ For $J^P = 2^+$ in the mass range 2222–2240 MeV and the total width between 10 and 20 MeV.

² For $J^P = 2^+$ and $J^P = 4^+$ in the mass range 2220–2245 MeV and the total width of 15 MeV.

³ For $J^P = 2^+$, the mass of 2235 MeV and the total width of 15 MeV.

$f_J(2220)$ BRANCHING RATIOS

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

| VALUE | DOCUMENT ID | COMMENT |
|----------|-----------------------|-------------------------------------|
| not seen | ¹ DOBBS 15 | $J/\psi \rightarrow \gamma\pi\pi$ |
| not seen | ¹ DOBBS 15 | $\psi(2S) \rightarrow \gamma\pi\pi$ |

¹ Using CLEO-c data but not authored by the CLEO Collaboration.

$$\Gamma(K\bar{K})/\Gamma_{\text{total}} \qquad \Gamma_3/\Gamma$$

| VALUE | DOCUMENT ID | COMMENT |
|----------|-----------------------|--|
| not seen | ¹ DOBBS 15 | $J/\psi \rightarrow \gamma K\bar{K}$ |
| not seen | ¹ DOBBS 15 | $\psi(2S) \rightarrow \gamma K\bar{K}$ |

¹ Using CLEO-c data but not authored by the CLEO Collaboration.

$$\Gamma(\pi\pi)/\Gamma(K\bar{K}) \qquad \Gamma_1/\Gamma_3$$

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

$$\Gamma(\rho\bar{\rho})/\Gamma_{\text{total}} \qquad \Gamma_4/\Gamma$$

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

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

| | | | | |
|----------|------|------------------------------|------|--|
| not seen | | ¹ AUBERT 07AV | BABR | $B \rightarrow \rho\bar{\rho}K^{(*)}$ |
| not seen | | WANG 05A | BELL | $B^+ \rightarrow \bar{\rho}\rho K^+$ |
| <3.0 | 95 | ² EVANGELIS... 97 | SPEC | 1.96–2.40 $\bar{\rho}\rho \rightarrow K_S^0 K_S^0$ |
| <1.1 | 99.7 | ³ BARNES 93 | SPEC | 1.3–1.57 $\bar{\rho}\rho \rightarrow K_S^0 K_S^0$ |
| <2.6 | 99.7 | ³ BARDIN 87 | CNTR | 1.3–1.5 $\bar{\rho}\rho \rightarrow K^+ K^-$ |
| <3.6 | 99.7 | ³ SCULLI 87 | CNTR | 1.29–1.55 $\bar{\rho}\rho \rightarrow K^+ K^-$ |

¹ Assuming $\Gamma < 30$ MeV.

² Assuming $\Gamma \sim 20$ MeV, $J^P = 2^+$ and $B(f_J(2220) \rightarrow K\bar{K}) = 100\%$.

³ Assuming $\Gamma = 30$ –35 MeV, $J^P = 2^+$ and $B(f_J(2220) \rightarrow K\bar{K}) = 100\%$.

$$\Gamma(\rho\bar{\rho})/\Gamma(K\bar{K}) \qquad \Gamma_4/\Gamma_3$$

| VALUE | DOCUMENT ID | TECN | COMMENT |
|--------------------|-------------|------|--|
| 0.17 ± 0.09 | BAI 96B | BES | $e^+e^- \rightarrow J/\psi \rightarrow \gamma\rho\bar{\rho}, K\bar{K}$ |

$f_J(2220)$ REFERENCES

| | | | |
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| | Translated from YAF 71 2166. | | |

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| WANG | 05A | PL B617 141 | M.-Z. Wang <i>et al.</i> | (BELLE Collab.) |
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| ACCIARRI | 01H | PL B501 173 | M. Acciarri <i>et al.</i> | (L3 Collab.) |
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| HASAN | 96 | PL B388 376 | A. Hasan, D.V. Bugg | (BRUN, LOQM) |
| BARNES | 93 | PL B309 469 | P.D. Barnes <i>et al.</i> | (PS185 Collab.) |
| ALBRECHT | 90G | ZPHY C48 183 | H. Albrecht <i>et al.</i> | (ARGUS Collab.) |
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