$\chi_{b2}(1P)$

$$I^G(J^{PC}) = 0^+(2^{++})$$
J needs confirmation.

Observed in radiative decay of the $\Upsilon(2S)$, therefore $C = +$. Branching ratio requires E1 transition, M1 is strongly disfavored, therefore $P = +$. $J = 2$ from SKWARNICKI 87.

$\chi_{b2}(1P)$ MASS

VALUE (MeV)	DOCUMENT ID
9912.21±0.26±0.31 OUR EVALUATION	From average γ energy below, using $\Upsilon(2S)$

mass $= 10023.26 \pm 0.31$ MeV

γ ENERGY IN $\Upsilon(2S)$ DECAY

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
110.44±0.29 OUR AVERAGE	Error includes scale factor of 1.1.			
110.58±0.08±0.30	ARTUSO	05	CLEO	$\Upsilon(2S) \to \gamma X$
110.8 ±0.3 ±0.6	EDWARDS	99	CLE2	$\Upsilon(2S) \to \gamma\chi(1P)$
107.0 ±1.1 ±1.3	WALK	86	CBAL	$\Upsilon(2S) \to \gamma\gamma\ell^+\ell^-$
110.6 ±0.3 ±0.9	ALBRECHT	85E	ARG	$\Upsilon(2S) \to$ conv. γX
110.4 ±0.8 ±2.2	NERNST	85	CBAL	$\Upsilon(2S) \to \gamma X$
109.5 ±0.7 ±1.0	HAAS	84	CLEO	$\Upsilon(2S) \to$ conv. γX
108.2 ±0.3 ±2.0	KLOPFEN...	83	CUSB	$\Upsilon(2S) \to \gamma X$
108.8 ±4.0	PAUSS	83	CUSB	$\Upsilon(2S) \to \gamma\gamma\ell^+\ell^-$

$\chi_{b2}(1P)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1	$\gamma\,\Upsilon(1S)$	$(22\ \pm4\ )\,\%$	
Γ_2	$D^0 X$	$<\ 7.9\ \ \ \ \%$	90%
Γ_3	$\pi^+\pi^- K^+ K^-\pi^0$	$(\ 8\ \pm5\ )\times 10^{-5}$	
Γ_4	$2\pi^+\pi^- K^- K^0_S$	$<\ 1.0\ \ \ \ \times 10^{-4}$	90%
Γ_5	$2\pi^+\pi^- K^- K^0_S 2\pi^0$	$(\ 5.3\pm2.4)\times 10^{-4}$	
Γ_6	$2\pi^+ 2\pi^- 2\pi^0$	$(\ 3.5\pm1.4)\times 10^{-4}$	
Γ_7	$2\pi^+ 2\pi^- K^+ K^-$	$(\ 1.1\pm0.4)\times 10^{-4}$	
Γ_8	$2\pi^+ 2\pi^- K^+ K^-\pi^0$	$(\ 2.1\pm0.9)\times 10^{-4}$	
Γ_9	$2\pi^+ 2\pi^- K^+ K^- 2\pi^0$	$(\ 3.9\pm1.8)\times 10^{-4}$	
Γ_{10}	$3\pi^+ 2\pi^- K^- K^0_S\pi^0$	$<\ 5\ \ \ \ \ \times 10^{-4}$	90%
Γ_{11}	$3\pi^+ 3\pi^-$	$(\ 7.0\pm3.1)\times 10^{-5}$	
Γ_{12}	$3\pi^+ 3\pi^- 2\pi^0$	$(\ 1.0\pm0.4)\times 10^{-3}$	
Γ_{13}	$3\pi^+ 3\pi^- K^+ K^-$	$<\ 8\ \ \ \ \ \times 10^{-5}$	90%
Γ_{14}	$3\pi^+ 3\pi^- K^+ K^-\pi^0$	$(\ 3.6\pm1.5)\times 10^{-4}$	
Γ_{15}	$4\pi^+ 4\pi^-$	$(\ 8\ \pm4\ )\times 10^{-5}$	
Γ_{16}	$4\pi^+ 4\pi^- 2\pi^0$	$(\ 1.8\pm0.7)\times 10^{-3}$	

$\chi_{b2}(1P)$ BRANCHING RATIOS

$\Gamma(\gamma\,\Upsilon(1S))/\Gamma_{\text{total}}$ $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.22±0.04 OUR AVERAGE				
0.27±0.06±0.06	WALK	86	CBAL	$\Upsilon(2S) \to \gamma\gamma\ell^+\ell^-$
0.20±0.05	KLOPFEN...	83	CUSB	$\Upsilon(2S) \to \gamma\gamma\ell^+\ell^-$

$\Gamma(D^0 X)/\Gamma_{\text{total}}$ $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ Γ_2/Γ

VALUE	CL%		DOCUMENT ID		TECN	COMMENT
<7.9 × 10^{-2}	90	[1,2]	BRIERE	08	CLEO	$\Upsilon(2S) \to \gamma D^0 X$

[1] For $p_{D^0} > 2.5$ GeV/c.

[2] The authors also present their result as $(5.4 \pm 1.9 \pm 0.5) \times 10^{-2}$.

$\Gamma(\pi^+\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}$ $\qquad\qquad\qquad\qquad\qquad\qquad$ Γ_3/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
0.84±0.50±0.04	8	[3]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma\pi^+\pi^- K^+ K^- \pi^0$

[3] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to \pi^+\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (6 \pm 3 \pm 2) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+\pi^- K^- K^0_S)/\Gamma_{\text{total}}$ $\qquad\qquad\qquad\qquad\qquad\qquad$ Γ_4/Γ

VALUE (units 10^{-4})	CL%		DOCUMENT ID		TECN	COMMENT
<1.0	90	[4]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 2\pi^+\pi^- K^- K^0_S$

[4] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 2\pi^+\pi^- K^- K^0_S)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] < 7 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = 7.15 \times 10^{-2}$.

$\Gamma(2\pi^+\pi^- K^- K^0_S 2\pi^0)/\Gamma_{\text{total}}$ $\qquad\qquad\qquad\qquad\qquad$ Γ_5/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
5.3±2.4±0.3	11	[5]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 2\pi^+\pi^- K^- 2\pi^0$

[5] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 2\pi^+\pi^- K^- K^0_S 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (38 \pm 14 \pm 10) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- 2\pi^0)/\Gamma_{\text{total}}$ $\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ Γ_6/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
3.5±1.4±0.2	19	[6]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 2\pi^+ 2\pi^- 2\pi^0$

[6] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 2\pi^+ 2\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (25 \pm 8 \pm 6) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{\text{total}}$ $\qquad$ Γ_7/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
1.1±0.4±0.1	14	[7]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 2\pi^+ 2\pi^- K^+ K^-$

[7] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (8 \pm 2 \pm 2) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}$ $\qquad$ Γ_8/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
2.1±0.9±0.1	13	[8]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 2\pi^+ 2\pi^- K^+ K^- \pi^0$

[8] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 2\pi^+ 2\pi^- K^+ K^- \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (15 \pm 5 \pm 4) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(2\pi^+ 2\pi^- K^+ K^- 2\pi^0)/\Gamma_{\text{total}}$ $\qquad$ Γ_9/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
3.9±1.8±0.2	11	[9]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 2\pi^+ 2\pi^- K^+ K^- 2\pi^0$

[9] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 2\pi^+ 2\pi^- K^+ K^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (28 \pm 11 \pm 7) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+ 2\pi^- K^- K_S^0 \pi^0)/\Gamma_{\text{total}}$ $\qquad$ Γ_{10}/Γ

VALUE (units 10^{-4})	CL%		DOCUMENT ID		TECN	COMMENT
<5	90	[10]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 3\pi^+ 2\pi^- K^- K_S^0 \pi^0$

[10] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 3\pi^+ 2\pi^- K^- K_S^0 \pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] < 36 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = 7.15 \times 10^{-2}$.

$\Gamma(3\pi^+ 3\pi^-)/\Gamma_{\text{total}}$ $\qquad$ Γ_{11}/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
0.70±0.31±0.03	9	[11]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 3\pi^+ 3\pi^-$

[11] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (5 \pm 2 \pm 1) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{\text{total}}$ $\qquad$ Γ_{12}/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
10.2±3.6±0.5	34	[12]	ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 3\pi^+ 3\pi^- 2\pi^0$

[12] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 3\pi^+ 3\pi^- 2\pi^0)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (73 \pm 16 \pm 20) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{total}$ Γ_{13}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<0.8	90	[13] ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 3\pi^+ 3\pi^- K^+ K^-$

[13] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 3\pi^+ 3\pi^- K^+ K^-)/\Gamma_{total}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] < 6 \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = 7.15 \times 10^{-2}$.

$\Gamma(3\pi^+ 3\pi^- K^+ K^- \pi^0)/\Gamma_{total}$ Γ_{14}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
3.6±1.5±0.2	14	[14] ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 3\pi^+ 3\pi^- K^+ K^- \pi^0$

[14] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 3\pi^+ 3\pi^- K^+ K^- \pi^0)/\Gamma_{total}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (26 \pm 8 \pm 7) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(4\pi^+ 4\pi^-)/\Gamma_{total}$ Γ_{15}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
0.84±0.40±0.04	7	[15] ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 4\pi^+ 4\pi^-$

[15] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 4\pi^+ 4\pi^-)/\Gamma_{total}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (6 \pm 2 \pm 2) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{total}$ Γ_{16}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
18±7±1	29	[16] ASNER	08A	CLEO	$\Upsilon(2S) \to \gamma 4\pi^+ 4\pi^- 2\pi^0$

[16] ASNER 08A reports $[\Gamma(\chi_{b2}(1P) \to 4\pi^+ 4\pi^- 2\pi^0)/\Gamma_{total}] \times [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] = (132 \pm 31 \pm 40) \times 10^{-6}$ which we divide by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = (7.15 \pm 0.35) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\chi_{b2}(1P)$ REFERENCES

ASNER	08A	PR D78 091103	D.M. Asner *et al.*	(CLEO Collab.)
BRIERE	08	PR D78 092007	R.A. Briere *et al.*	(CLEO Collab.)
ARTUSO	05	PRL 94 032001	M. Artuso *et al.*	(CLEO Collab.)
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ALBRECHT	85E	PL 160B 331	H. Albrecht *et al.*	(ARGUS Collab.)
NERNST	85	PRL 54 2195	R. Nernst *et al.*	(Crystal Ball Collab.)
HAAS	84	PRL 52 799	J. Haas *et al.*	(CLEO Collab.)
KLOPFEN...	83	PRL 51 160	C. Klopfenstein *et al.*	(CUSB Collab.)
PAUSS	83	PL 130B 439	F. Pauss *et al.*	(MPIM, COLU, CORN, LSU+)