

$\chi_{b2}(2P)$

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

J needs confirmation.

Observed in radiative decay of the $\Upsilon(3S)$, therefore $C = +$. Branching ratio requires E1 transition, M1 is strongly disfavored, therefore $P = +$.

$\chi_{b2}(2P)$ MASS

VALUE (GeV)	DOCUMENT ID
10.26865 ± 0.00022 ± 0.00050 OUR EVALUATION	From γ energy below, using $\Upsilon(3S)$ mass = 10355.2 ± 0.5 MeV

$m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)}$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
13.5 ± 0.4 ± 0.5	¹ HEINTZ	92	CSB2 $e^+e^- \rightarrow \gamma X, \ell^+ \ell^- \gamma \gamma$

¹From the average photon energy for inclusive and exclusive events. Supersedes NARAIN 91.

γ ENERGY IN $\Upsilon(3S)$ DECAY

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
86.19 ± 0.22 OUR EVALUATION		Treating systematic errors as correlated		
86.40 ± 0.18 OUR AVERAGE				
86.04 ± 0.06 ± 0.27		ARTUSO	05	CLEO $\Upsilon(3S) \rightarrow \gamma X$
86 ± 1	101	CRAWFORD	92B	CLE2 $e^+e^- \rightarrow \ell^+ \ell^- \gamma \gamma$
86.7 ± 0.4	10319	² HEINTZ	92	CSB2 $e^+e^- \rightarrow \gamma X$
86.9 ± 0.4	157	³ HEINTZ	92	CSB2 $e^+e^- \rightarrow \ell^+ \ell^- \gamma \gamma$
86.4 ± 0.1 ± 0.4	30741	MORRISON	91	CLE2 $e^+e^- \rightarrow \gamma X$

²A systematic uncertainty on the energy scale of 0.9% not included. Supersedes NARAIN 91.

³A systematic uncertainty on the energy scale of 0.9% not included. Supersedes HEINTZ 91.

$\chi_{b2}(2P)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 $\omega \Upsilon(1S)$	(1.10 ^{+0.34} _{-0.30}) %
Γ_2 $\gamma \Upsilon(2S)$	(16.2 ± 2.4) %
Γ_3 $\gamma \Upsilon(1S)$	(7.1 ± 1.0) %
Γ_4 $\pi\pi\chi_{b2}(1P)$	(6.0 ± 2.1) × 10 ⁻³

$\chi_{b2}(2P)$ BRANCHING RATIOS

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

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
1.10^{+0.32+0.11}_{-0.28-0.10}	20.1 ^{+5.8} _{-5.1}	⁴ CRONIN-HEN..04	CLE3	$\Upsilon(3S) \rightarrow \gamma \omega \Upsilon(1S)$

⁴ Using $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = (11.4 \pm 0.8)\%$ and $B(\Upsilon(1S) \rightarrow \ell^+ \ell^-) = 2 B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = 2 (2.48 \pm 0.06)\%$.

$\Gamma(\gamma \Upsilon(2S))/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.162\pm0.024 OUR AVERAGE			
0.135 \pm 0.025 \pm 0.035	⁵ CRAWFORD 92B	CLE2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$
0.173 \pm 0.021 \pm 0.019	⁶ HEINTZ 92	CSB2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$

⁵ Using $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.37 \pm 0.26)\%$, $B(\Upsilon(3S) \rightarrow \gamma \gamma \Upsilon(2S)) \times 2 B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (4.98 \pm 0.94 \pm 0.62) \times 10^{-4}$, and $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = 0.135 \pm 0.003 \pm 0.017$.

⁶ Using $B(\Upsilon(2S) \rightarrow \mu^+ \mu^-) = (1.44 \pm 0.10)\%$, $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = (11.1 \pm 0.5 \pm 0.4)\%$ and assuming $e\mu$ universality. Supersedes HEINTZ 91.

$\Gamma(\gamma \Upsilon(1S))/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.071\pm0.010 OUR AVERAGE			
0.072 \pm 0.014 \pm 0.013	⁷ CRAWFORD 92B	CLE2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$
0.070 \pm 0.010 \pm 0.006	⁸ HEINTZ 92	CSB2	$e^+ e^- \rightarrow \ell^+ \ell^- \gamma \gamma$

⁷ Using $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.57 \pm 0.07)\%$, $B(\Upsilon(3S) \rightarrow \gamma \gamma \Upsilon(2S)) \times 2 B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (5.03 \pm 0.94 \pm 0.63) \times 10^{-4}$, and $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = 0.135 \pm 0.003 \pm 0.017$.

⁸ Using $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.57 \pm 0.07)\%$, $B(\Upsilon(3S) \rightarrow \gamma \chi_{b2}(2P)) = (11.1 \pm 0.5 \pm 0.4)\%$ and assuming $e\mu$ universality. Supersedes HEINTZ 91.

$\Gamma(\pi \pi \chi_{b2}(1P))/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE (units 10^{-3})	DOCUMENT ID	TECN	COMMENT
6.0\pm1.6\pm1.4	⁹ CAWLFIELD 06	CLE3	$\Upsilon(3S) \rightarrow 2(\gamma \pi \ell)$

⁹ CAWLFIELD 06 quote $\Gamma(\chi_b(2P) \rightarrow \pi \pi \chi_b(1P)) = 0.83 \pm 0.22 \pm 0.08 \pm 0.19$ keV assuming l-spin conservation, no D-wave contribution, $\Gamma(\chi_{b1}(2P)) = 96 \pm 16$ keV, and $\Gamma(\chi_{b2}(2P)) = 138 \pm 19$ keV.

$\chi_{b2}(2P)$ REFERENCES

CAWLFIELD 06	PR D73 012003	C. Cawfield <i>et al.</i>	(CLEO Collab.)
ARTUSO 05	PRL 94 032001	M. Artuso <i>et al.</i>	(CLEO Collab.)
CRONIN-HEN...04	PRL 92 222002	D. Cronin-Hennessy <i>et al.</i>	(CLEO3 Collab.)
CRAWFORD 92B	PL B294 139	G. Crawford, R. Fulton	(CLEO Collab.)
HEINTZ 92	PR D46 1928	U. Heintz <i>et al.</i>	(CUSB II Collab.)
HEINTZ 91	PRL 66 1563	U. Heintz <i>et al.</i>	(CUSB Collab.)
MORRISON 91	PRL 67 1696	R.J. Morrison <i>et al.</i>	(CLEO Collab.)
NARAIN 91	PRL 66 3113	M. Narain <i>et al.</i>	(CUSB Collab.)

OTHER RELATED PAPERS

EIGEN 82	PRL 49 1616	G. Eigen <i>et al.</i>	(CUSB Collab.)
HAN 82	PRL 49 1612	K. Han <i>et al.</i>	(CUSB Collab.)