

# $\chi_{b1}(2P)$

$$J^G(J^{PC}) = 0^+(1^{++})$$

$J$  needs confirmation.

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

## $\chi_{b1}(2P)$ MASS

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
<b>10.2552 ± 0.0005 OUR AVERAGE</b>			
10.2547 ± 0.0004 ± 0.0010	<sup>1</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma X, \ell^+\ell^- \gamma\gamma$
10.2553 ± 0.0005	<sup>2</sup> MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$

<sup>1</sup> From the average photon energy for inclusive and exclusive events and assuming  $\Upsilon(3S)$  mass = 10355.3 ± 0.5 MeV. Supersedes HEINTZ 91 and NARAIN 91.

<sup>2</sup> From  $\gamma$  energy below assuming  $\Upsilon(3S)$  mass = 10355.3 ± 0.5 MeV. The error on the  $\Upsilon(3S)$  mass is not included in the individual measurements. It is included in the final evaluation.

## $m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)}$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>23.5 ± 0.7 ± 0.7</b>			
	<sup>3</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma X, \ell^+\ell^- \gamma\gamma$

<sup>3</sup> From the average photon energy for inclusive and exclusive events. Supersedes NARAIN 91.

## $\gamma$ ENERGY IN $\Upsilon(3S)$ DECAY

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>99.90 ± 0.26 OUR AVERAGE</b>				
99 ± 1	169	CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^- \gamma\gamma$
100.1 ± 0.4	11147	<sup>4</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma X$
100.2 ± 0.5	223	<sup>5</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^- \gamma\gamma$
99.5 ± 0.1 ± 0.5	25759	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$

<sup>4</sup> A systematic uncertainty on the energy scale of 0.9% not included. Supersedes NARAIN 91.

<sup>5</sup> A systematic uncertainty on the energy scale of 0.9% not included. Supersedes HEINTZ 91.

## $\chi_{b1}(2P)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor
$\Gamma_1 \quad \gamma \Upsilon(2S)$	(21 ± 4) %	1.5
$\Gamma_2 \quad \gamma \Upsilon(1S)$	( 8.5 ± 1.3) %	1.3

## $\chi_{b1}(2P)$ BRANCHING RATIOS

$\Gamma(\gamma \Upsilon(2S))/\Gamma_{\text{total}}$   $\Gamma_1/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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**0.21 ± 0.04 OUR AVERAGE** Error includes scale factor of 1.5.

0.356 ± 0.042 ± 0.092	<sup>6</sup> CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
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0.199 ± 0.020 ± 0.022	<sup>7</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
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<sup>6</sup> Using  $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.37 \pm 0.26)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma\gamma \Upsilon(2S)) \times 2 B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (10.23 \pm 1.20 \pm 1.26) \times 10^{-4}$ , and  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = 0.105^{+0.003}_{-0.002} \pm 0.013$ .

<sup>7</sup> Using  $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.44 \pm 0.10)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (11.5 \pm 0.5 \pm 0.5)\%$  and assuming  $e\mu$  universality. Supersedes HEINTZ 91.

$\Gamma(\gamma \Upsilon(1S))/\Gamma_{\text{total}}$   $\Gamma_2/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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**0.085 ± 0.013 OUR AVERAGE** Error includes scale factor of 1.3.

0.120 ± 0.021 ± 0.021	<sup>8</sup> CRAWFORD	92B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
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0.080 ± 0.009 ± 0.007	<sup>9</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
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<sup>8</sup> Using  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.07)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma\gamma \Upsilon(1S)) \times 2 B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (6.47 \pm 1.12 \pm 0.82) \times 10^{-4}$  and  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = 0.105^{+0.003}_{-0.002} \pm 0.013$ .

<sup>9</sup> Using  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.07)\%$ ,  $B(\Upsilon(3S) \rightarrow \gamma \chi_{b1}(2P)) = (11.5 \pm 0.5 \pm 0.5)\%$  and assuming  $e\mu$  universality. Supersedes HEINTZ 91.

## $\chi_{b1}(2P)$ REFERENCES

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.)