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

$I^G(J^{PC}) = 0^+(1^{++})$
$J$ 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* |
|---|---|---|---|---|
| **10.2552±0.0005 OUR AVERAGE** | | | | |
| 10.2547±0.0004±0.0010 | [1] HEINTZ | 92 | CSB2 | $e^+e^- \to \gamma X, \ell^+\ell^-\gamma\gamma$ |
| 10.2553±0.0005 | [2] MORRISON | 91 | CLE2 | $e^+e^- \to \gamma X$ |

[1] 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.

[2] 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* |
|---|---|---|---|---|
| **23.5±0.7±0.7** | [3] HEINTZ | 92 | CSB2 | $e^+e^- \to \gamma X, \ell^+\ell^-\gamma\gamma$ |

[3] 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* |
|---|---|---|---|---|---|
| **99.90±0.26 OUR AVERAGE** | | | | | |
| 99 ±1 | 169 | CRAWFORD | 92B | CLE2 | $e^+e^- \to \ell^+\ell^-\gamma\gamma$ |
| 100.1 ±0.4 | 11147 | [4] HEINTZ | 92 | CSB2 | $e^+e^- \to \gamma X$ |
| 100.2 ±0.5 | 223 | [5] HEINTZ | 92 | CSB2 | $e^+e^- \to \ell^+\ell^-\gamma\gamma$ |
| 99.5 ±0.1 ±0.5 | 25759 | MORRISON | 91 | CLE2 | $e^+e^- \to \gamma X$ |

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

[5] 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 |
|---|---|---|---|
| $\Gamma_1$ | $\gamma\,\Upsilon(2S)$ | (21 ±4 ) % | 1.5 |
| $\Gamma_2$ | $\gamma\,\Upsilon(1S)$ | ( 8.5±1.3) % | 1.3 |

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

## $\Gamma(\gamma\,\Upsilon(2S))/\Gamma_{total}$ — $\Gamma_1/\Gamma$

| *VALUE* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **0.21 ±0.04 OUR AVERAGE** | Error includes scale factor of 1.5. | | | |
| $0.356\pm0.042\pm0.092$ | [6] CRAWFORD | 92B | CLE2 | $e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$ |
| $0.199\pm0.020\pm0.022$ | [7] HEINTZ | 92 | CSB2 | $e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$ |

[6] Using B($\Upsilon(2S) \rightarrow \mu^+\mu^-$) = $(1.37\pm0.26)$%, B($\Upsilon(3S) \rightarrow \gamma\gamma\,\Upsilon(2S)$)$\times$2 B($\Upsilon(2S) \rightarrow \mu^+\mu^-$) = $(10.23\pm1.20\pm1.26)\times10^{-4}$, and B($\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)$) = $0.105^{+0.003}_{-0.002}\pm0.013$.

[7] Using B($\Upsilon(2S) \rightarrow \mu^+\mu^-$) = $(1.44\pm0.10)$%, B($\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)$) = $(11.5\pm0.5\pm0.5)$% and assuming $e\mu$ universality. Supersedes HEINTZ 91.

## $\Gamma(\gamma\,\Upsilon(1S))/\Gamma_{total}$ — $\Gamma_2/\Gamma$

| *VALUE* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **0.085±0.013 OUR AVERAGE** | Error includes scale factor of 1.3. | | | |
| $0.120\pm0.021\pm0.021$ | [8] CRAWFORD | 92B | CLE2 | $e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$ |
| $0.080\pm0.009\pm0.007$ | [9] HEINTZ | 92 | CSB2 | $e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$ |

[8] Using B($\Upsilon(1S) \rightarrow \mu^+\mu^-$) = $(2.57\pm0.07)$%, B($\Upsilon(3S) \rightarrow \gamma\gamma\,\Upsilon(1S)$)$\times$2 B($\Upsilon(1S) \rightarrow \mu^+\mu^-$) = $(6.47\pm1.12\pm0.82)\times10^{-4}$ and B($\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)$) = $0.105^{+0.003}_{-0.002}\pm0.013$.

[9] Using B($\Upsilon(1S) \rightarrow \mu^+\mu^-$)=$(2.57\pm0.07)$%, B($\Upsilon(3S) \rightarrow \gamma\chi_{b1}(2P)$) = $(11.5\pm0.5\pm0.5)$% and assuming $e\mu$ universality. Supersedes HEINTZ 91.

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


| | | | | |
|---|---|---|---|---|
| CRAWFORD | 92B | PL B294 139 | +Fulton | (CLEO Collab.) |
| HEINTZ | 92 | PR D46 1928 | +Lee, Franzini+ | (CUSB II Collab.) |
| HEINTZ | 91 | PRL 66 1563 | +Kaarsberg+ | (CUSB Collab.) |
| MORRISON | 91 | PRL 67 1696 | +Schmidt+ | (CLEO Collab.) |
| NARAIN | 91 | PRL 66 3113 | +Lovelock+ | (CUSB Collab.) |


## OTHER RELATED PAPERS


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