

$\Upsilon(1D)$

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

First observed by BONVICINI 04 in the decay to $\gamma\gamma \Upsilon(1S)$ and confirmed by DEL-AMO-SANCHEZ 10R in the decay to $\pi^+\pi^- \Upsilon(1S)$. Data consistent with $J^P = 2^-$. The states with $J = 1$ and 3 also possibly seen, but need confirmation.

$\Upsilon(1D)$ MASS

| VALUE (MeV) | EVTS | DOCUMENT ID | TECN | COMMENT |
|--------------------------------|------|-------------------------------------|------|---|
| 10163.7±1.4 OUR AVERAGE | | Error includes scale factor of 1.7. | | |
| 10164.5±0.8±0.5 | | DEL-AMO-SA...10R | BABR | $\Upsilon(3S) \rightarrow \gamma\gamma\pi^+\pi^-\ell^+\ell^-$ |
| 10161.1±0.6±1.6 | 38 | BONVICINI 04 | CLE3 | $\Upsilon(3S) \rightarrow 4\gamma\ell^+\ell^-$ |

$\Upsilon(1D)$ DECAY MODES

| Mode | Fraction (Γ_i/Γ) |
|--|--------------------------------|
| $\Gamma_1 \quad \gamma\gamma \Upsilon(1S)$ | seen |
| $\Gamma_2 \quad \gamma\chi_{bJ}(1P)$ | seen |
| $\Gamma_3 \quad \eta \Upsilon(1S)$ | not seen |
| $\Gamma_4 \quad \pi^+\pi^- \Upsilon(1S)$ | $(6.6\pm 1.6) \times 10^{-3}$ |

$\Upsilon(1D)$ BRANCHING RATIOS

| $\Gamma(\eta \Upsilon(1S))/\Gamma(\gamma\gamma \Upsilon(1S))$ | | | | | Γ_3/Γ_1 |
|---|-----|--------------|------|--|---------------------|
| VALUE | CL% | DOCUMENT ID | TECN | COMMENT | |
| <0.25 | 90 | BONVICINI 04 | CLE3 | $\Upsilon(3S) \rightarrow 4\gamma\ell^+\ell^-$ | |

| $\Gamma(\pi^+\pi^- \Upsilon(1S))/\Gamma_{\text{total}}$ | | | | | Γ_4/Γ |
|---|--|-------------------------------|------|---|-------------------|
| VALUE (units 10^{-2}) | | DOCUMENT ID | TECN | COMMENT | |
| $0.66^{+0.15}_{-0.14} \pm 0.06$ | | ¹ DEL-AMO-SA...10R | BABR | $\Upsilon(3S) \rightarrow \gamma\gamma\pi^+\pi^-\ell^+\ell^-$ | |

¹ Using theoretical predictions for $B(\chi_{bJ}(2P) \rightarrow \gamma \Upsilon(1D))$.

| $\Gamma(\pi^+\pi^- \Upsilon(1S))/\Gamma(\gamma\gamma \Upsilon(1S))$ | | | | | Γ_4/Γ_1 |
|---|-----|---------------------------|------|--|---------------------|
| VALUE | CL% | DOCUMENT ID | TECN | COMMENT | |
| <1.2 | 90 | ² BONVICINI 04 | CLE3 | $\Upsilon(3S) \rightarrow 4\gamma\ell^+\ell^-$ | |

² Assuming $J = 2$.

$\Upsilon(1D)$ REFERENCES

| | | | |
|-------------------|---------------|----------------------------------|-----------------|
| DEL-AMO-SA... 10R | PR D82 111102 | P. del Amo Sanchez <i>et al.</i> | (BABAR Collab.) |
| BONVICINI 04 | PR D70 032001 | G. Bonvicini <i>et al.</i> | (CLEO Collab.) |