

$b\bar{b}$ MESONS

 $\Upsilon(1S)$

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

 Mass $m = 9460.37 \pm 0.21$ MeV (S = 2.7)

 Full width $\Gamma = 52.5 \pm 1.8$ keV

 $\Gamma_{ee} = 1.32 \pm 0.05$ keV

$\Upsilon(1S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\tau^+ \tau^-$	$(2.67^{+0.14}_{-0.16}) \%$		4384
$e^+ e^-$	$(2.52 \pm 0.17) \%$		4730
$\mu^+ \mu^-$	$(2.48 \pm 0.07) \%$	S=1.1	4729
Hadronic decays			
$J/\psi(1S)$ anything	$(1.1 \pm 0.4) \times 10^{-3}$		4223
$\rho\pi$	< 2	$\times 10^{-4}$ CL=90%	4698
$\pi^+ \pi^-$	< 5	$\times 10^{-4}$ CL=90%	4728
$K^+ K^-$	< 5	$\times 10^{-4}$ CL=90%	4704
$p\bar{p}$	< 5	$\times 10^{-4}$ CL=90%	4636

Radiative decays

$\gamma 2h^+ 2h^-$	$(7.0 \pm 1.5) \times 10^{-4}$		4720
$\gamma 3h^+ 3h^-$	$(5.4 \pm 2.0) \times 10^{-4}$		4703
$\gamma 4h^+ 4h^-$	$(7.4 \pm 3.5) \times 10^{-4}$		4679
$\gamma \pi^+ \pi^- K^+ K^-$	$(2.9 \pm 0.9) \times 10^{-4}$		4686
$\gamma 2\pi^+ 2\pi^-$	$(2.5 \pm 0.9) \times 10^{-4}$		4720
$\gamma 3\pi^+ 3\pi^-$	$(2.5 \pm 1.2) \times 10^{-4}$		4703
$\gamma 2\pi^+ 2\pi^- K^+ K^-$	$(2.4 \pm 1.2) \times 10^{-4}$		4658
$\gamma \pi^+ \pi^- p \bar{p}$	$(1.5 \pm 0.6) \times 10^{-4}$		4604
$\gamma 2\pi^+ 2\pi^- p \bar{p}$	$(4 \pm 6) \times 10^{-5}$		4563
$\gamma 2K^+ 2K^-$	$(2.0 \pm 2.0) \times 10^{-5}$		4601
$\gamma \eta'(958)$	< 1.3	$\times 10^{-3}$	CL=90% 4682
$\gamma \eta$	< 3.5	$\times 10^{-4}$	CL=90% 4714
$\gamma f'_2(1525)$	< 1.4	$\times 10^{-4}$	CL=90% 4607
$\gamma f_2(1270)$	< 1.3	$\times 10^{-4}$	CL=90% 4644
$\gamma \eta(1440)$	< 8.2	$\times 10^{-5}$	CL=90% 4624
$\gamma f_J(1710) \rightarrow \gamma K \bar{K}$	< 2.6	$\times 10^{-4}$	CL=90% 4576
$\gamma f_0(2200) \rightarrow \gamma K^+ K^-$	< 2	$\times 10^{-4}$	CL=90% 4475
$\gamma f_J(2220) \rightarrow \gamma K^+ K^-$	< 1.5	$\times 10^{-5}$	CL=90% 4469
$\gamma \eta(2225) \rightarrow \gamma \phi \phi$	< 3	$\times 10^{-3}$	CL=90% 4469
γX	< 3	$\times 10^{-5}$	CL=90% -
$X = \text{pseudoscalar with } m < 7.2 \text{ GeV}$			
$\gamma X \bar{X}$	< 1	$\times 10^{-3}$	CL=90% -
$X \bar{X} = \text{vectors with } m < 3.1 \text{ GeV}$			

 $\chi_{b0}(1P)$ [jjj]

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

 J needs confirmation.

$$\text{Mass } m = 9859.8 \pm 1.3 \text{ MeV}$$

$\chi_{b0}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\gamma \Upsilon(1S)$	$< 6\%$	90%	391

 $\chi_{b1}(1P)$ [jjj]

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

 J needs confirmation.

$$\text{Mass } m = 9891.9 \pm 0.7 \text{ MeV}$$

$\chi_{b1}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma \Upsilon(1S)$	$(35 \pm 8)\%$	422

$\chi_{b2}(1P)$ [iii]

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

 J needs confirmation.Mass $m = 9913.2 \pm 0.6$ MeV

$\chi_{b2}(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma \Upsilon(1S)$	(22±4) %	443

 $\Upsilon(2S)$

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

Mass $m = 10.02330 \pm 0.00031$ GeVFull width $\Gamma = 44 \pm 7$ keV $\Gamma_{ee} = 0.520 \pm 0.032$ keV

$\Upsilon(2S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Upsilon(1S)\pi^+\pi^-$	(18.5 ± 0.8) %		475
$\Upsilon(1S)\pi^0\pi^0$	(8.8 ± 1.1) %		480
$\tau^+\tau^-$	(1.7 ± 1.6) %		4686
$\mu^+\mu^-$	(1.31±0.21) %		5011
e^+e^-	(1.18±0.20) %		5012
$\Upsilon(1S)\pi^0$	< 8	$\times 10^{-3}$	90% 531
$\Upsilon(1S)\eta$	< 2	$\times 10^{-3}$	90% 127
$J/\psi(1S)$ anything	< 6	$\times 10^{-3}$	90% 4533

Radiative decays

$\gamma \chi_{b1}(1P)$	(6.7 ± 0.9) %		131
$\gamma \chi_{b2}(1P)$	(6.6 ± 0.9) %		110
$\gamma \chi_{b0}(1P)$	(4.3 ± 1.0) %		162
$\gamma f_J(1710)$	< 5.9	$\times 10^{-4}$	90% 4866
$\gamma f'_2(1525)$	< 5.3	$\times 10^{-4}$	90% 4896
$\gamma f_2(1270)$	< 2.41	$\times 10^{-4}$	90% 4931

 $\chi_{b0}(2P)$ [iii]

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

 J needs confirmation.Mass $m = 10.2321 \pm 0.0006$ GeV

$\chi_{b0}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma \Upsilon(2S)$	(4.6±2.1) %	210
$\gamma \Upsilon(1S)$	(9 ± 6) $\times 10^{-3}$	746

$\chi_{b1}(2P)$ [iii]

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

 J needs confirmation.

$$\text{Mass } m = 10.2552 \pm 0.0005 \text{ GeV}$$

$$m_{\chi_{b1}(2P)} - m_{\chi_{b0}(2P)} = 23.5 \pm 1.0 \text{ MeV}$$

$\chi_{b1}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor	p (MeV/c)
$\gamma \Upsilon(2S)$	(21 \pm 4) %	1.5	229
$\gamma \Upsilon(1S)$	(8.5 \pm 1.3) %	1.3	764

 $\chi_{b2}(2P)$ [iii]

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

 J needs confirmation.

$$\text{Mass } m = 10.2685 \pm 0.0004 \text{ GeV}$$

$$m_{\chi_{b2}(2P)} - m_{\chi_{b1}(2P)} = 13.5 \pm 0.6 \text{ MeV}$$

$\chi_{b2}(2P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$\gamma \Upsilon(2S)$	(16.2 \pm 2.4) %	242
$\gamma \Upsilon(1S)$	(7.1 \pm 1.0) %	776

 $\Upsilon(3S)$

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

$$\text{Mass } m = 10.3553 \pm 0.0005 \text{ GeV}$$

$$\text{Full width } \Gamma = 26.3 \pm 3.5 \text{ keV}$$

$\Upsilon(3S)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$\Upsilon(2S)$ anything	(10.6 \pm 0.8) %		296
$\Upsilon(2S) \pi^+ \pi^-$	(2.8 \pm 0.6) %	S=2.2	177
$\Upsilon(2S) \pi^0 \pi^0$	(2.00 \pm 0.32) %		190
$\Upsilon(2S) \gamma \gamma$	(5.0 \pm 0.7) %		327
$\Upsilon(1S) \pi^+ \pi^-$	(4.48 \pm 0.21) %		814
$\Upsilon(1S) \pi^0 \pi^0$	(2.06 \pm 0.28) %		816
$\Upsilon(1S) \eta$	< 2.2 $\times 10^{-3}$	CL=90%	—
$\mu^+ \mu^-$	(1.81 \pm 0.17) %		5177
$e^+ e^-$	seen		5177
Radiative decays			
$\gamma \chi_{b2}(2P)$	(11.4 \pm 0.8) %	S=1.3	87
$\gamma \chi_{b1}(2P)$	(11.3 \pm 0.6) %		100
$\gamma \chi_{b0}(2P)$	(5.4 \pm 0.6) %	S=1.1	123

**$\Upsilon(4S)$
or $\Upsilon(10580)$**

$$I^G(J^{PC}) = ??(1^{--})$$

 Mass $m = 10.5800 \pm 0.0035$ GeV

 Full width $\Gamma = 10 \pm 4$ MeV

 $\Gamma_{ee} = 0.248 \pm 0.031$ keV ($S = 1.3$)

$\Upsilon(4S)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$B\bar{B}$	> 96 %	95%	—
non- $B\bar{B}$	< 4 %	95%	—
e^+e^-	$(2.8 \pm 0.7) \times 10^{-5}$		5290
$J/\psi(3097)$ anything	$(2.2 \pm 0.7) \times 10^{-3}$		—
D^{*+} anything + c.c.	< 7.4 %	90%	5099
ϕ anything	< 2.3 $\times 10^{-3}$	90%	5240
$\Upsilon(1S)$ anything	< 4 $\times 10^{-3}$	90%	1053

 $\Upsilon(10860)$

$$I^G(J^{PC}) = ??(1^{--})$$

 Mass $m = 10.865 \pm 0.008$ GeV ($S = 1.1$)

 Full width $\Gamma = 110 \pm 13$ MeV

 $\Gamma_{ee} = 0.31 \pm 0.07$ keV ($S = 1.3$)

$\Upsilon(10860)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(2.8 \pm 0.7) \times 10^{-6}$	5432

 $\Upsilon(11020)$

$$I^G(J^{PC}) = ??(1^{--})$$

 Mass $m = 11.019 \pm 0.008$ GeV

 Full width $\Gamma = 79 \pm 16$ MeV

 $\Gamma_{ee} = 0.130 \pm 0.030$ keV

$\Upsilon(11020)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	$(1.6 \pm 0.5) \times 10^{-6}$	5509