Lezione 22

Quarkonia

$\phi(1020)\ \ (s,\overline{s})$ $\qquad$ $J/\psi(3096)\ \ (c,\overline{c})$ $\qquad$ $\Upsilon(9460)\ \ (b,\overline{b})$

Masse di J/ψ e Υ molto grandi.

Piccolo accoppiamento con quark u, d, s.

Vista la massa grande sono trattati con modelli di MQ non relativistica.

Analogia con sistemi noti, positronio.

Positronio

Sistema legato e^-, e^+, vita media 10^{-10} s .

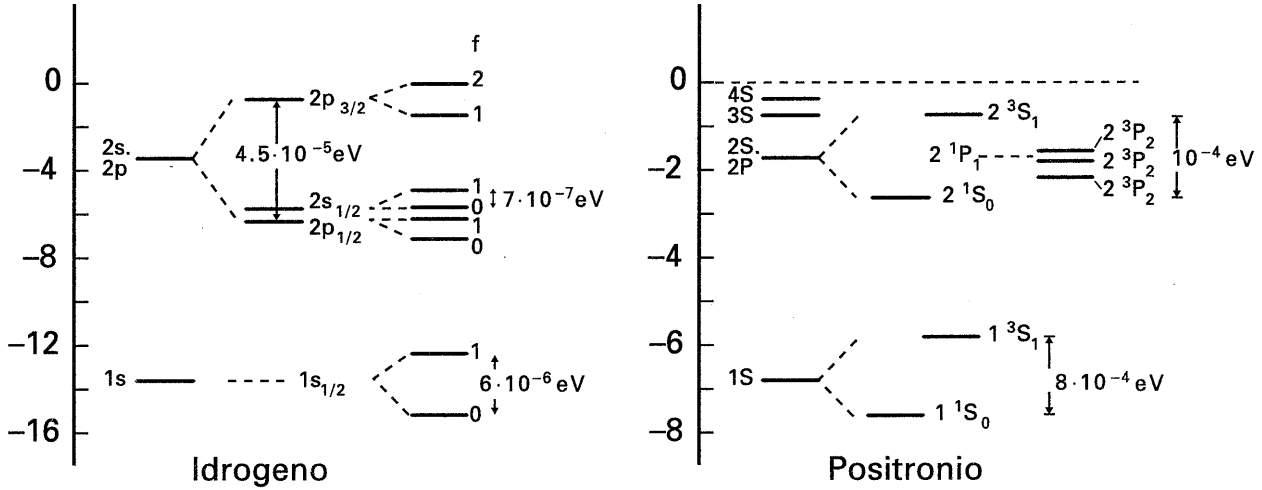
Gli spin possono formare sistemi con $S = 0$ oppure $S = 1$.

Lo stato con $S = 0$ decade in due fotoni per conservare il momento angolare.

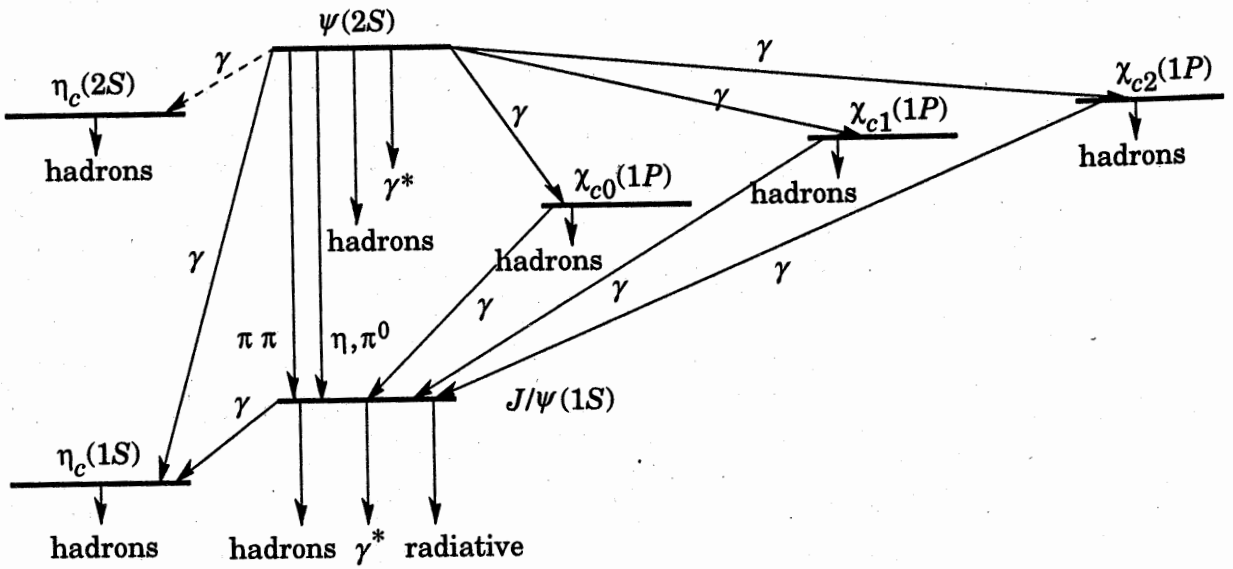
Lo stato con $S = 1$ decade in tre fotoni. Non può decadere in un singolo fotone per conservazione di energia e impulso.

Misura γ spettro di eccitazione del sistema.

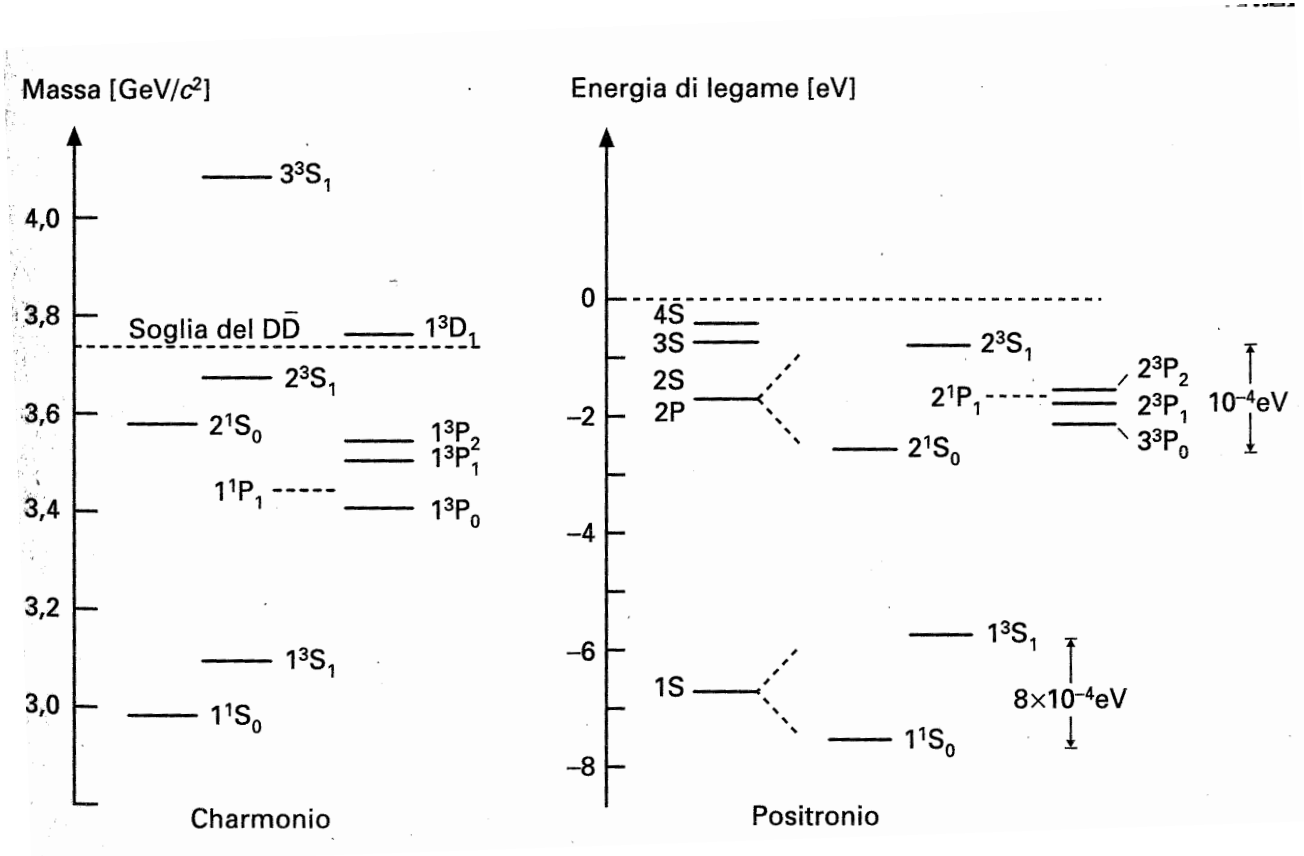
Confronto con l'atomo di idrogeno.


0
−4
−8
−12
−16
2s, 2p
1s
2p 3/2
2s 1/2
2p 1/2
1s 1/2
4.5·10 −5eV
f
2
1
1
0
1
0
1
0
↕7·10−7eV
↕6·10−6eV
Idrogeno
0
−2
−4
−6
−8
4S
3S
2S, 2P
1S
2 3S1
2 1P1
2 1S0
2 3P2
2 3P2
2 3P2
10−4 eV
1 3S1
1 1S0
8·10−4 eV
Positronio

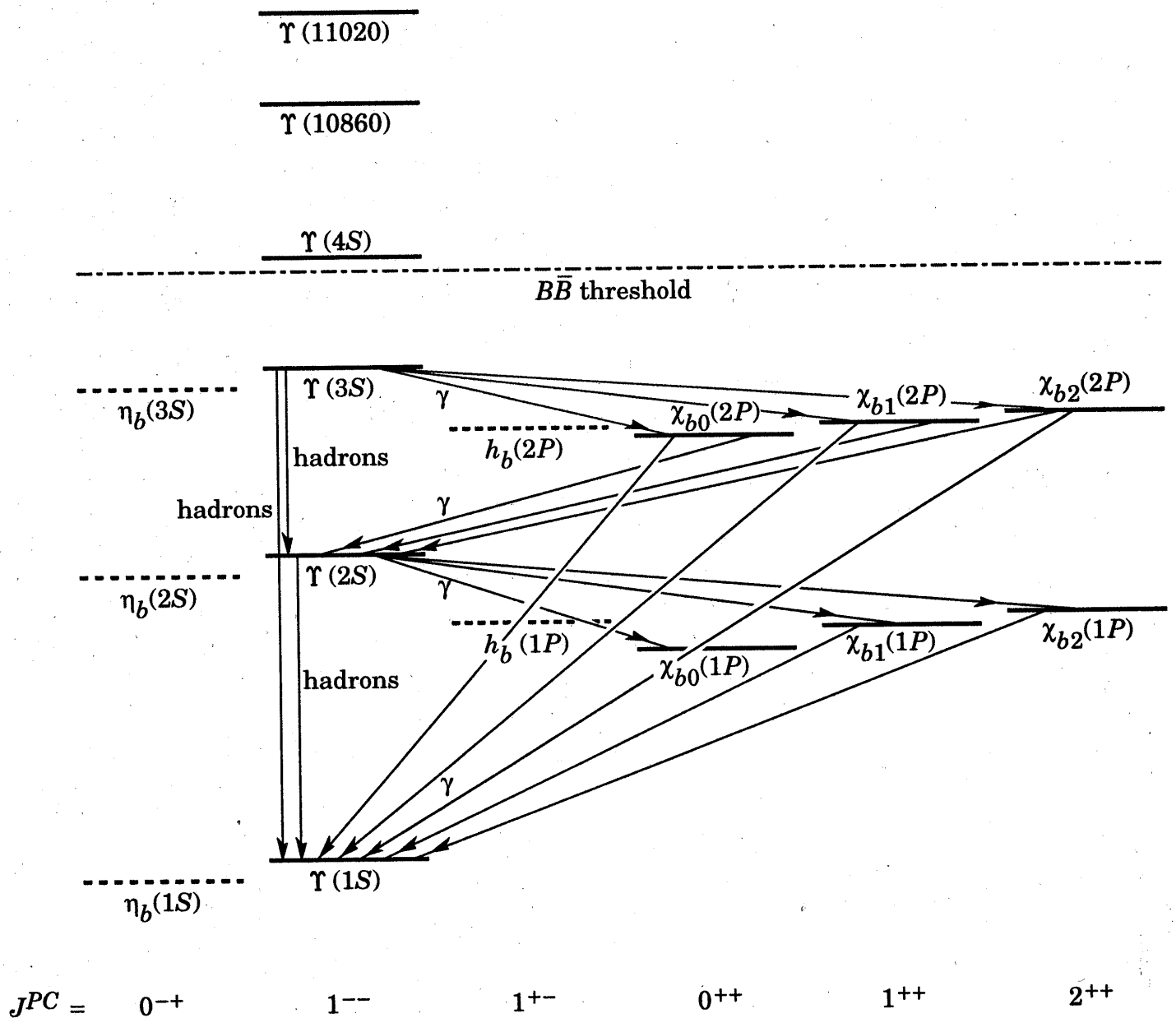
THE CHARMONIUM SYSTEM

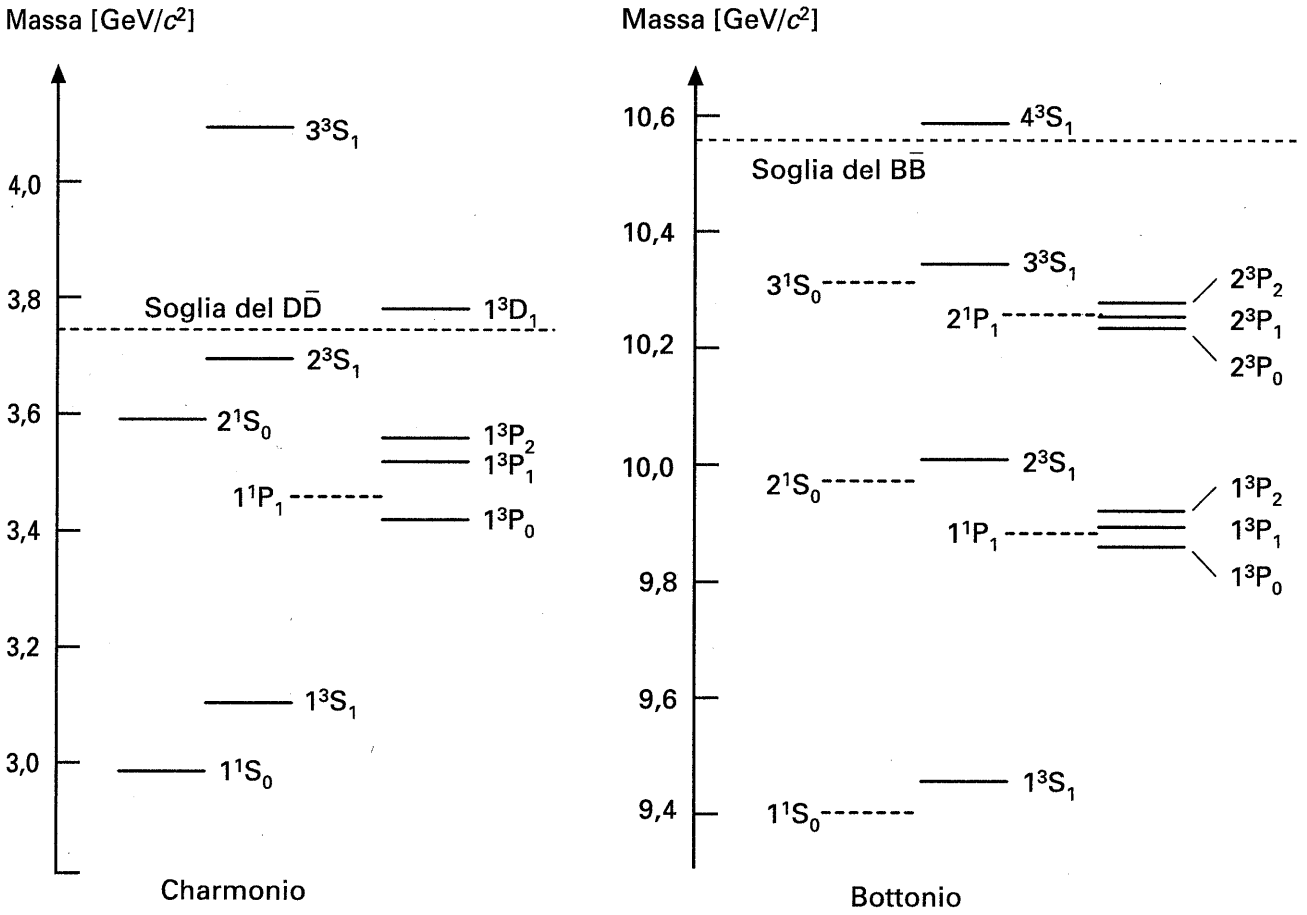


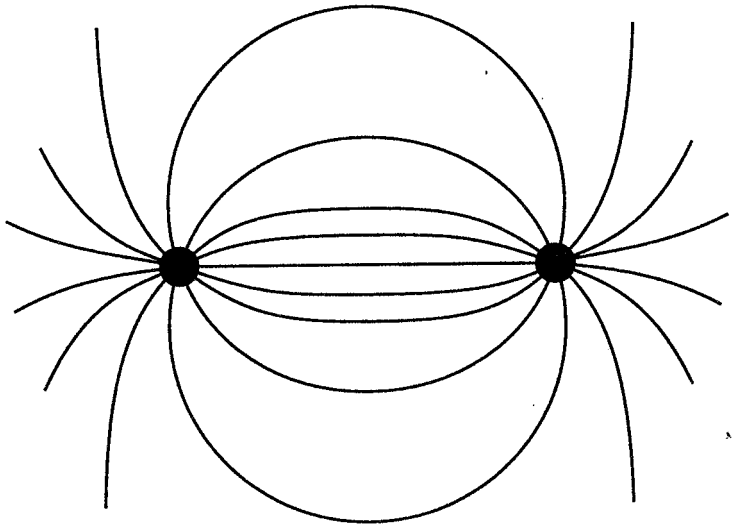
J^{PC} = 0^{-+} 1^{--} 0^{++} 1^{++} 2^{++}

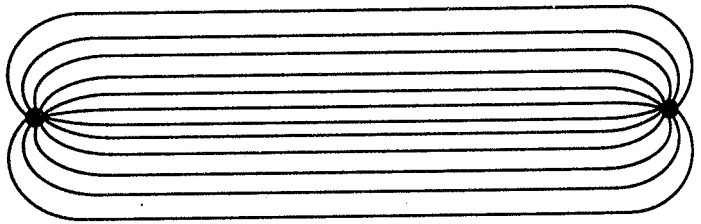

Massa [GeV/c^2]
4,0
3,8
3,6
3,4
3,2
3,0
3^3S_1
Soglia del $D\bar{D}$
1^3D_1
2^3S_1
2^1S_0
1^3P_2
1^3P_1
1^1P_1
1^3P_0
1^3S_1
1^1S_0
Charmonio
Energia di legame [eV]
0
−2
−4
−6
−8
4S
3S
2S
2P
1S
2^3S_1
2^1S_0
2^1P_1
2^3P_2
2^3P_1
3^3P_0
10^{-4}eV
1^3S_1
1^1S_0
8×10^{-4}eV
Positronio

Bottomio


Υ (11020)
Υ (10860)
Υ (4S)
$B\bar{B}$ threshold
Υ (3S)
$\eta_b(3S)$
hadrons
$h_b(2P)$
$\chi_{b0}(2P)$
$\chi_{b1}(2P)$
$\chi_{b2}(2P)$
γ
hadrons
Υ (2S)
$\eta_b(2S)$
$h_b(1P)$
$\chi_{b0}(1P)$
$\chi_{b1}(1P)$
$\chi_{b2}(1P)$
hadrons
Υ (1S)
$\eta_b(1S)$
J^{PC} = 0⁻⁺ 1⁻⁻ 1⁺⁻ 0⁺⁺ 1⁺⁺ 2⁺⁺

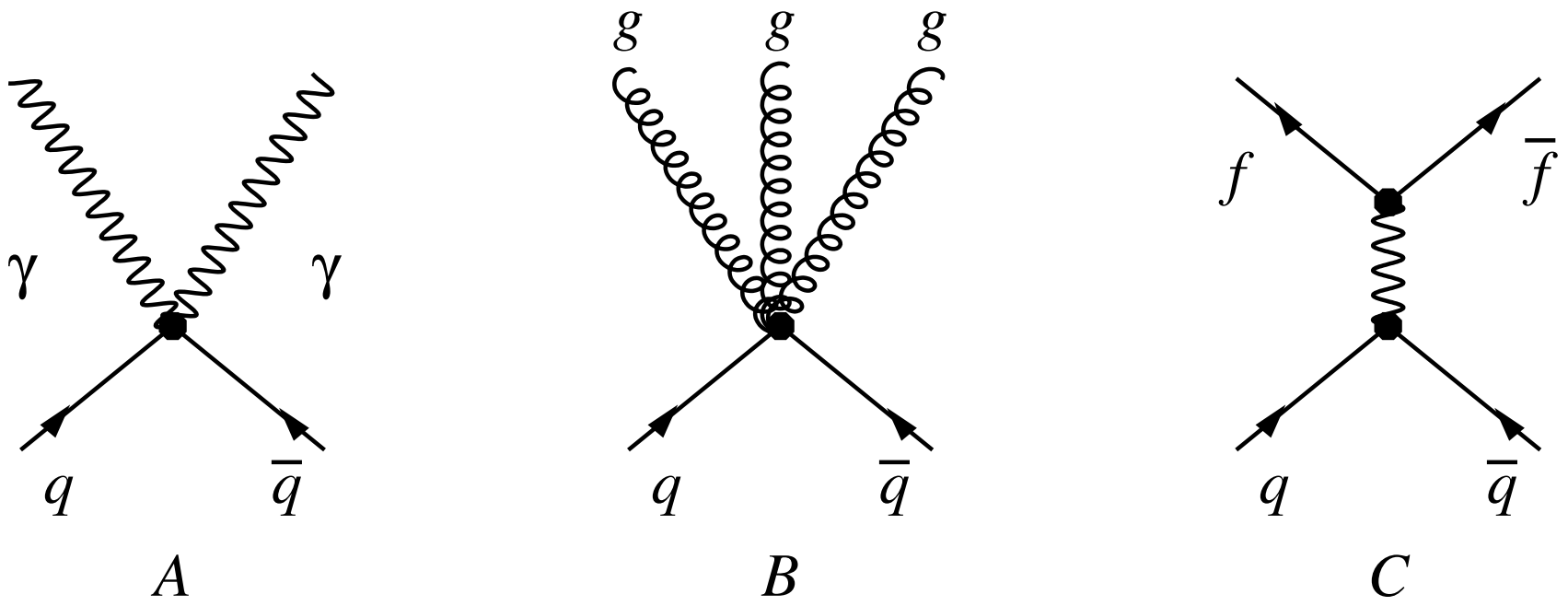

Massa [GeV/c^2]
4,0
3,8
3,6
3,4
3,2
3,0
3^3S_1
Soglia del $D\bar{D}$
1^3D_1
2^3S_1
2^1S_0
1^3P_2
1^3P_1
1^1P_1
1^3P_0
1^3S_1
1^1S_0
Charmonio
Massa [GeV/c^2]
10,6
10,4
10,2
10,0
9,8
9,6
9,4
4^3S_1
Soglia del $B\bar{B}$
3^3S_1
3^1S_0
2^1P_1
2^3P_2
2^3P_1
2^3P_0
2^3S_1
2^1S_0
1^3P_2
1^1P_1
1^3P_1
1^3P_0
1^3S_1
1^1S_0
Bottonio





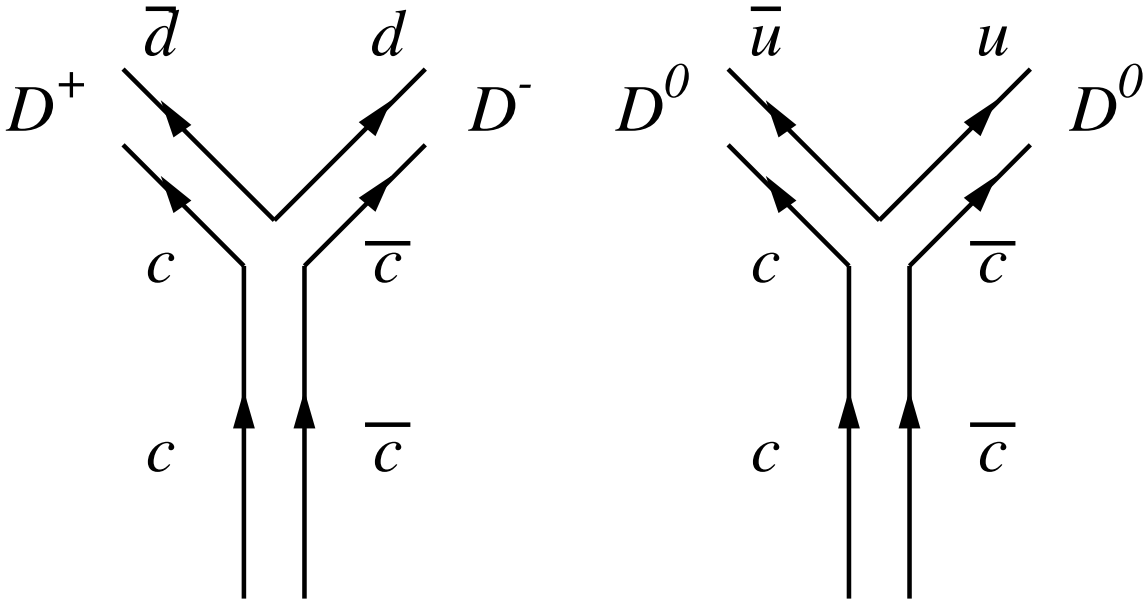
$$V = -\frac{4}{3}\frac{\alpha_s \hbar c}{r} + kr$$

Decadimento quarkonia



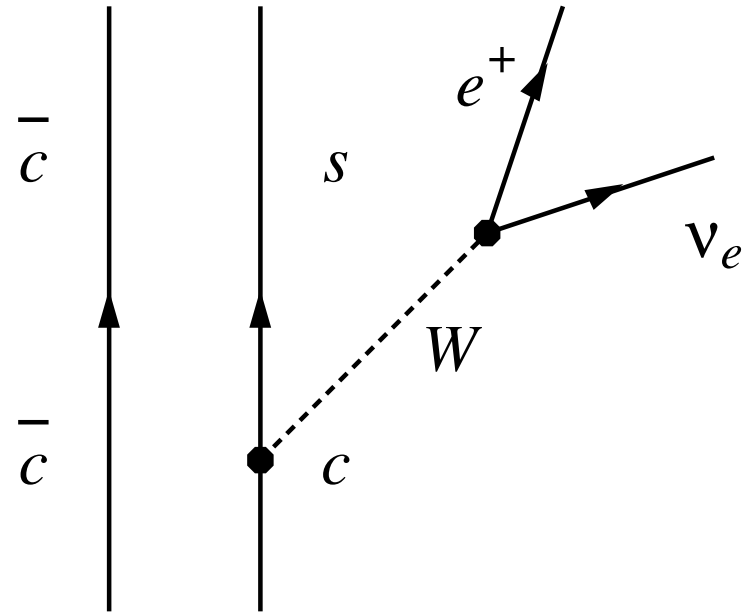
annichilazione

Decadimento quarkonia



Creazione di una coppia $q\ \overline{q}$

Decadimento quarkonia

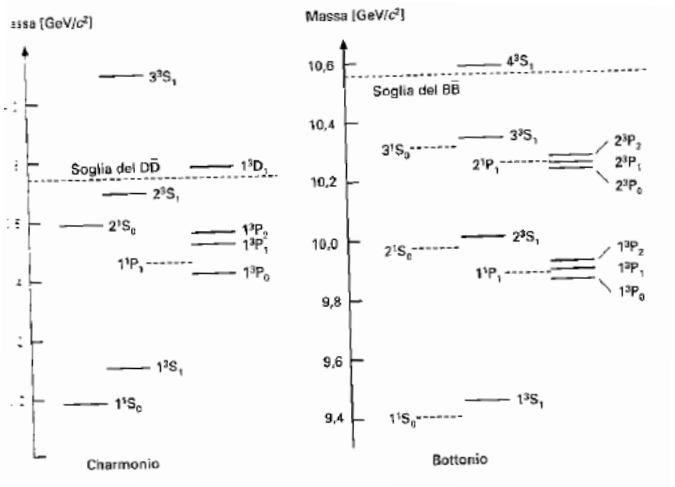


Decadimento debole, di almeno un quark

Domande

[P1-7] Cosa sono il bottonio e charmonio ?

[P3-10]



Nella figura qual è il significato della linea indicata come $D\overline{D}$?