

Lezione 22

# Quarkonia

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

Massa di  $J/\psi$  e  $\Upsilon$  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 .

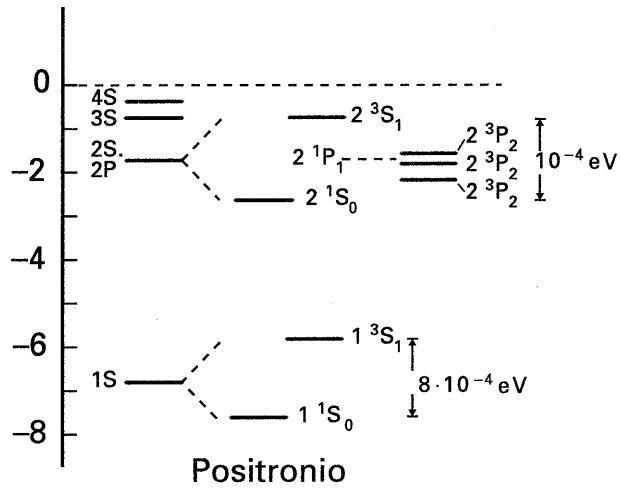
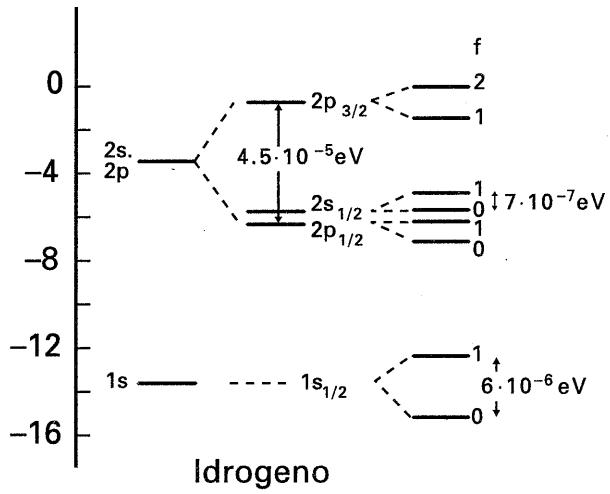
Gli spin possono formare sistemi con  $S = 0$  oppure  $S = 1$ .

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

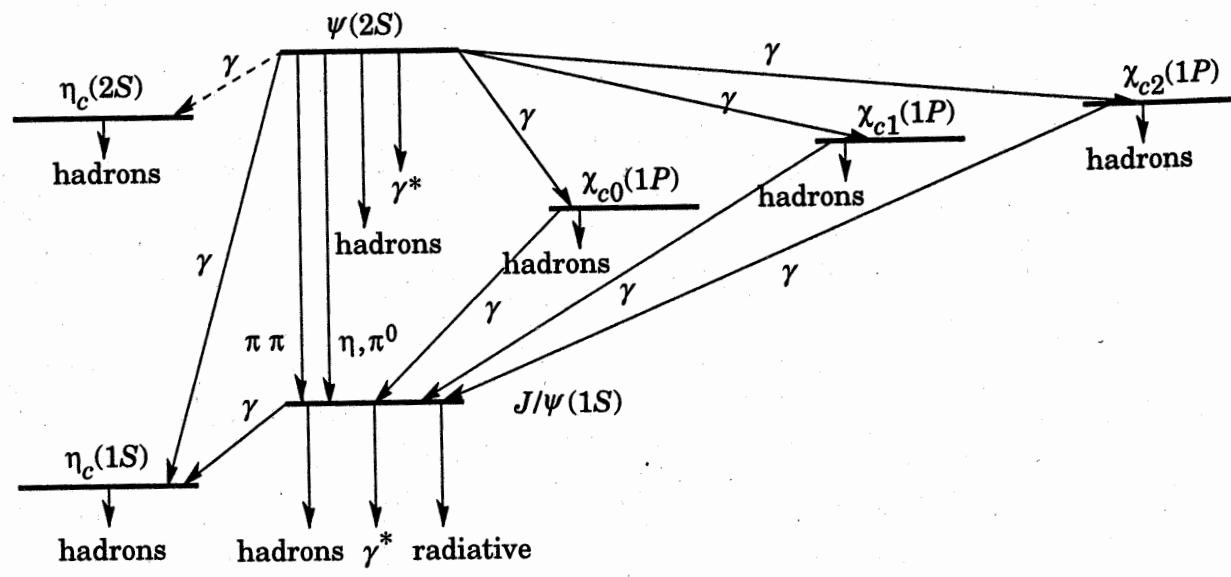
Lo stato con  $S = 1$  decade in tre fotoni. Non può decadere in un singolo fotone per conservazione di energia e impulso.

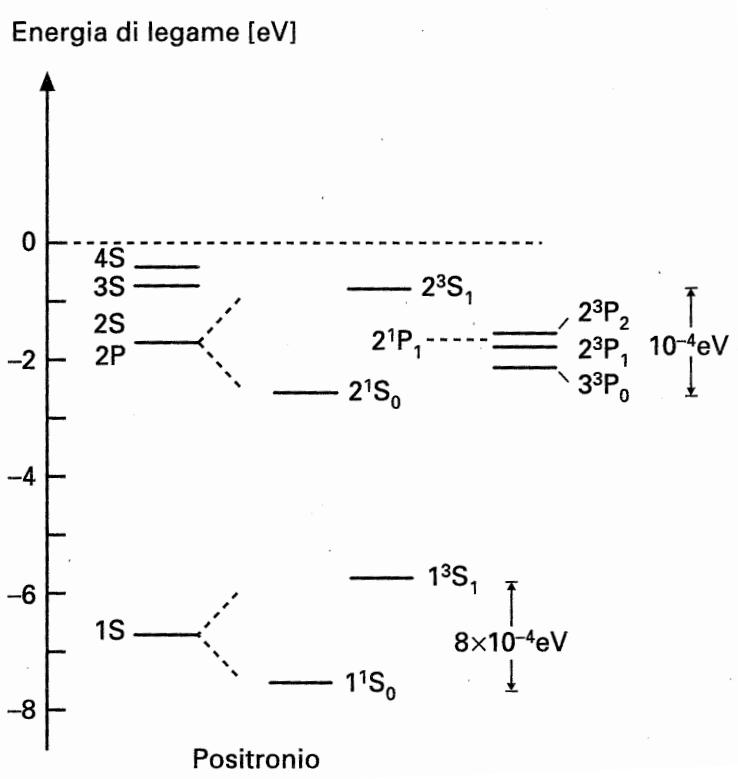
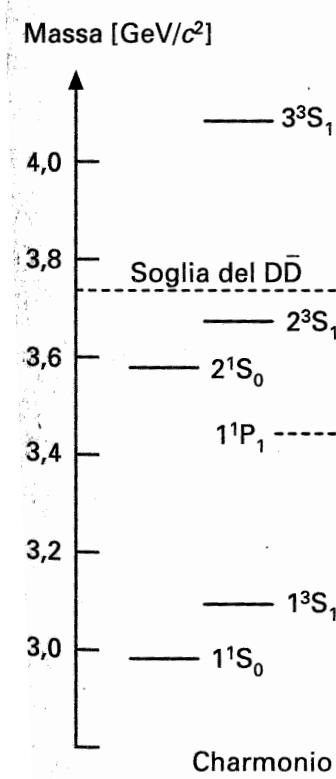
Misura  $\gamma$  spettro di eccitazione del sistema.

Confronto con l'atomo di idrogeno.

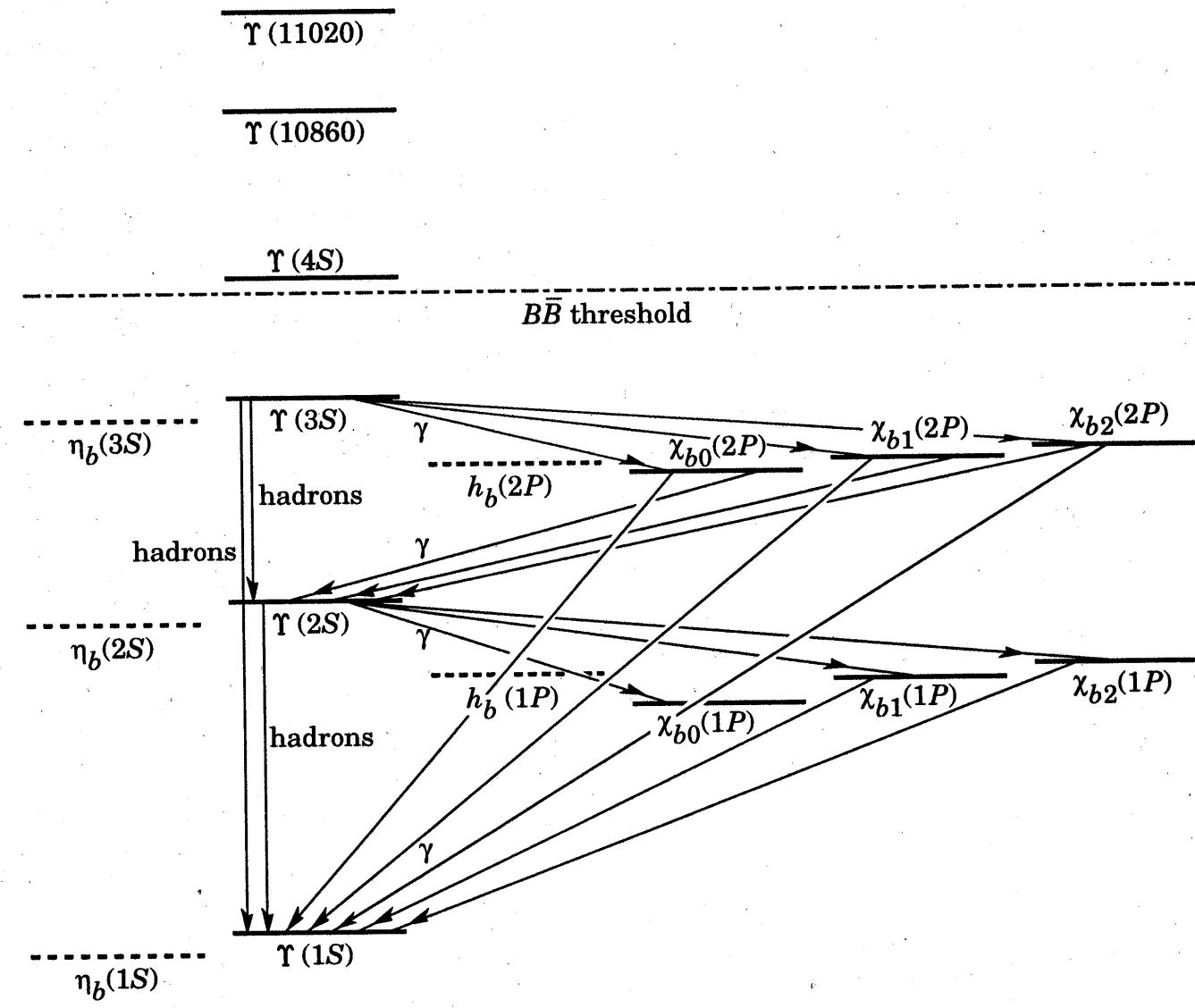


## THE CHARMONIUM SYSTEM



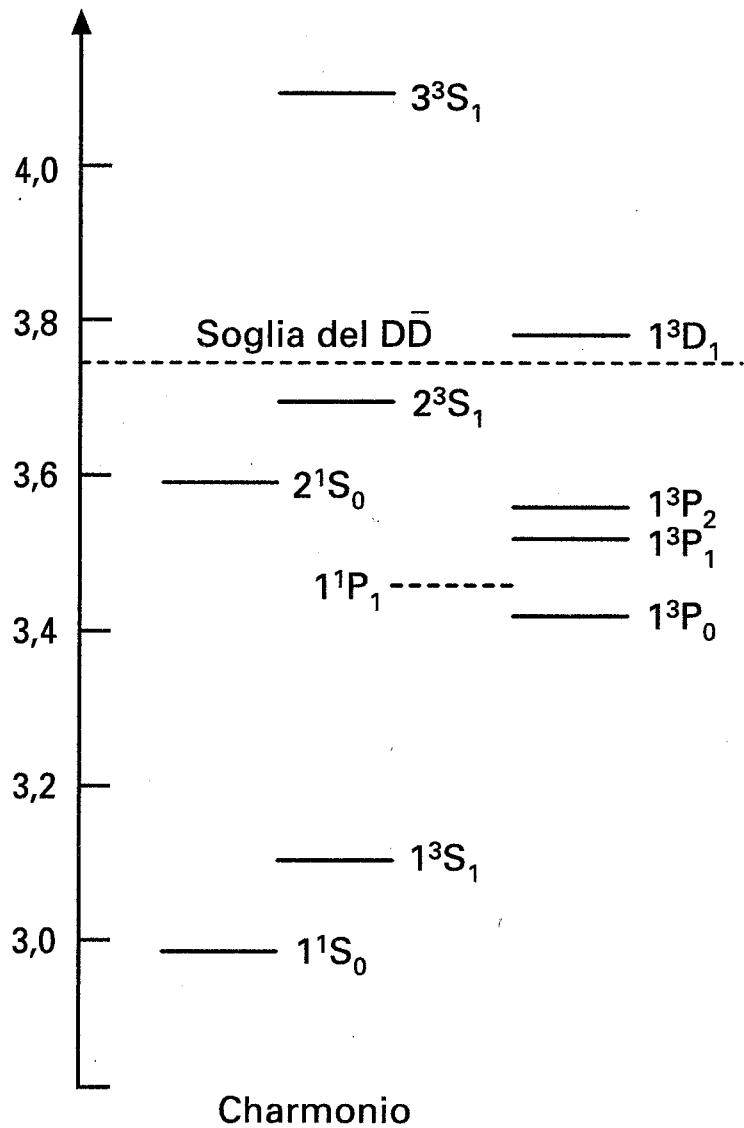


# Bottomio



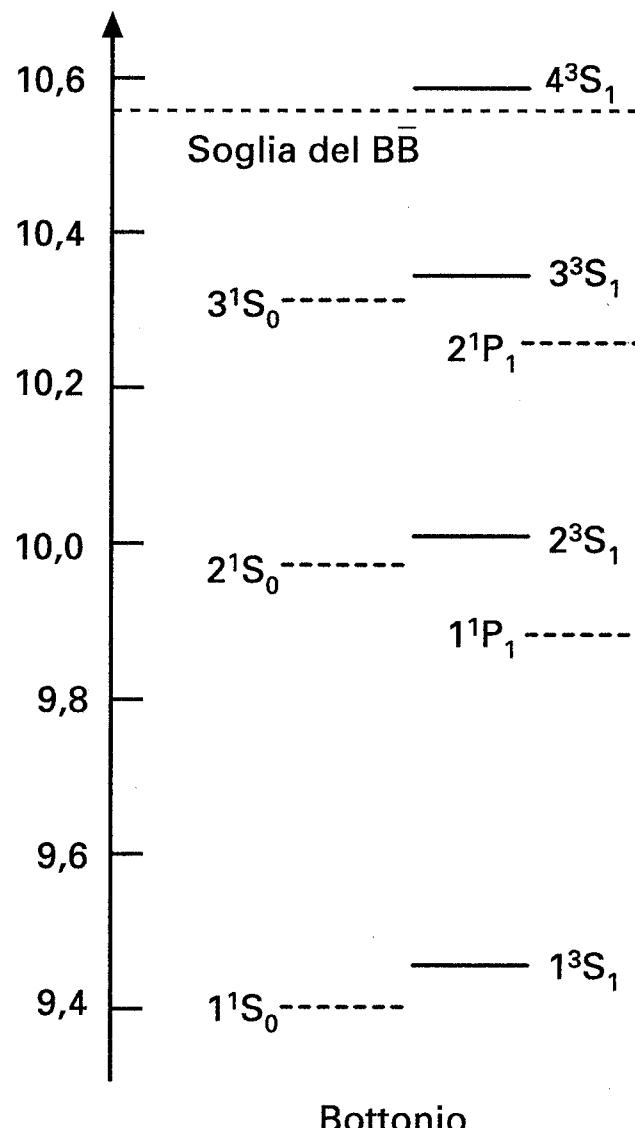
$$JPC = \quad 0^{-+} \quad \quad \quad 1^{--} \quad \quad \quad 1^{+-} \quad \quad \quad 0^{++} \quad \quad \quad 1^{++} \quad \quad \quad 2^{++}$$

Massa [ $\text{GeV}/c^2$ ]

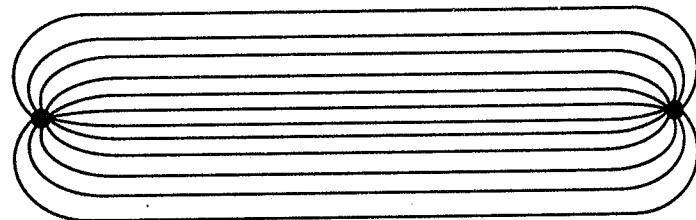
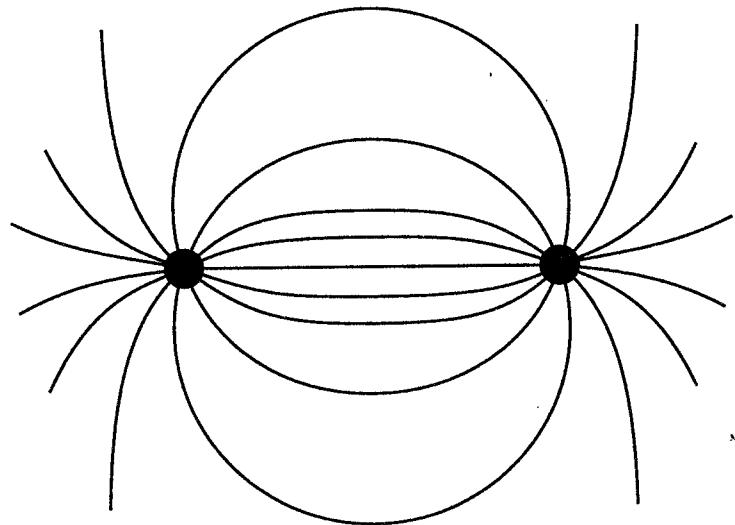


Charmonio

Massa [ $\text{GeV}/c^2$ ]

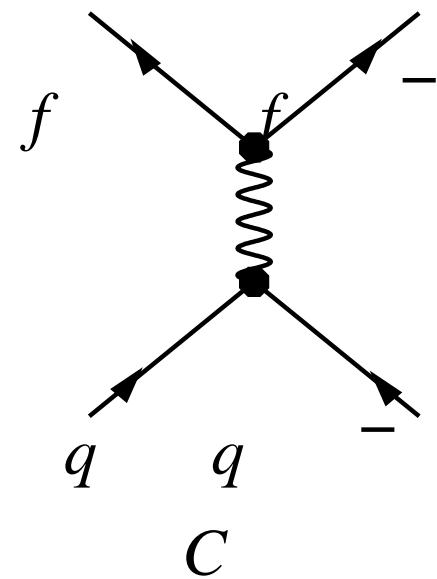
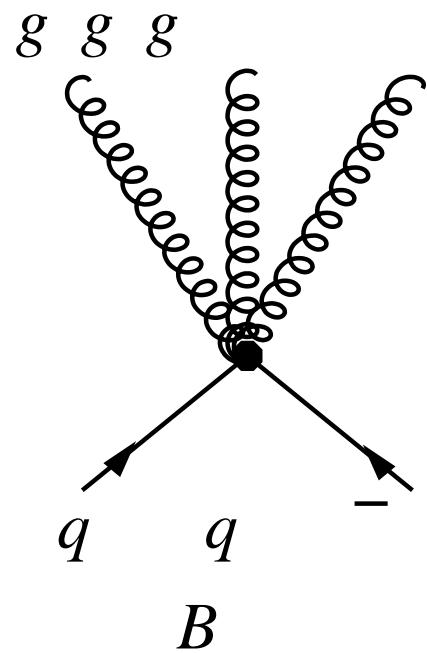
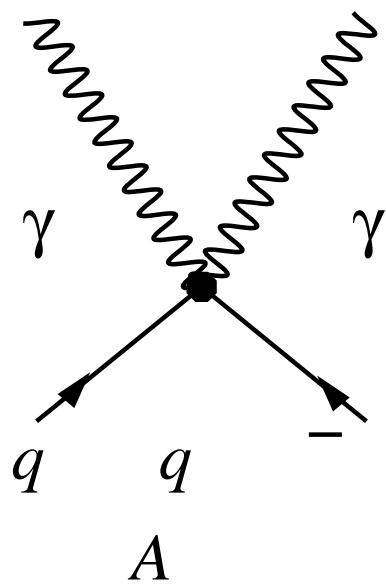


Bottonio



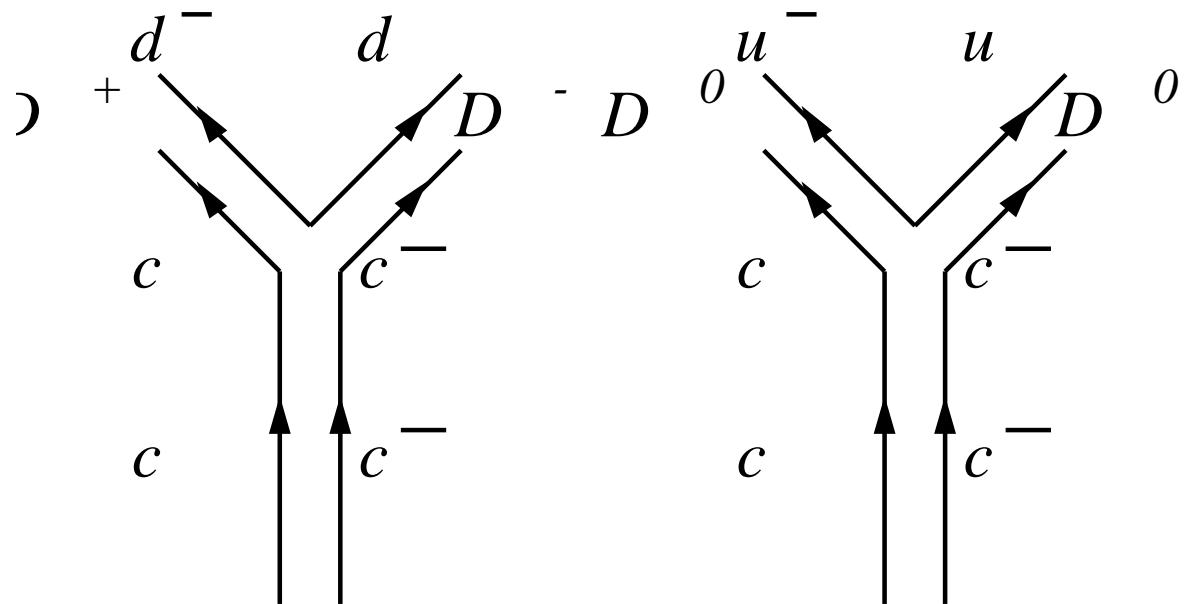
$$V = -\frac{4}{3} \frac{\alpha_s \hbar c}{r} + kr$$

## Decadimento quarkonia



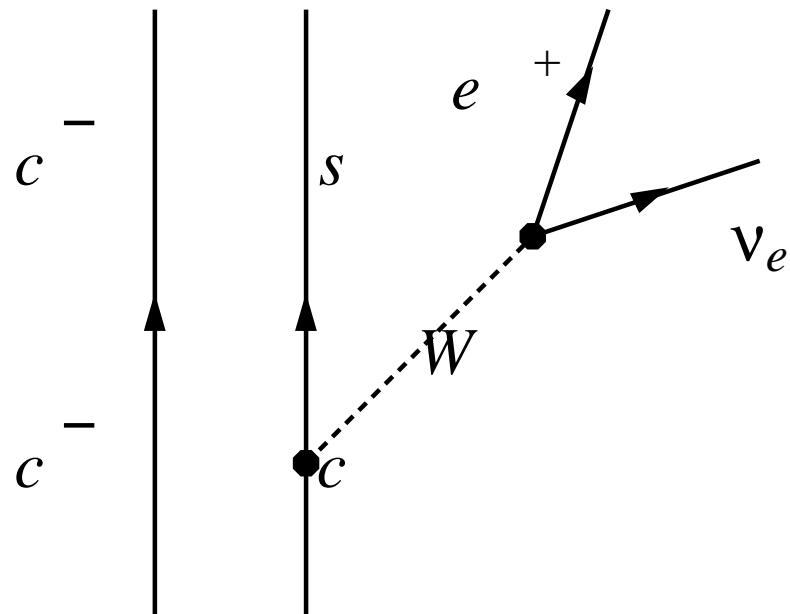
annichilazione

## Decadimento quarkonia



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

## Decadimento quarkonia



Decadimento debole, di almeno un quark

## Domande

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