Dynamical gluon mass corrections in heavy quarkonia decays

A, A. Natale - *IFT* - *Unesp*

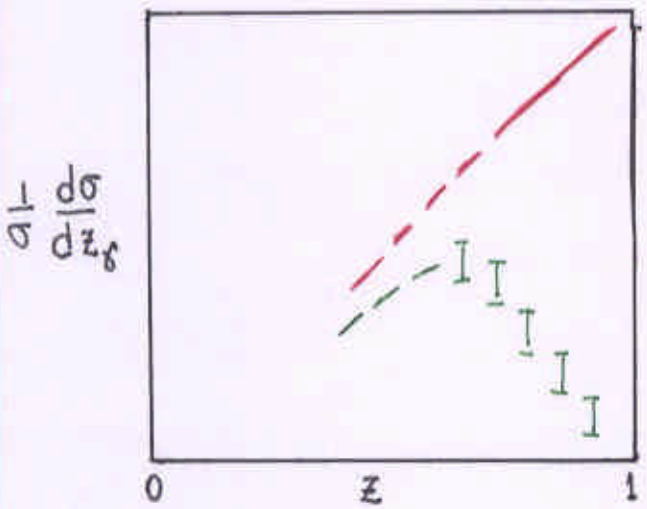
hadronic/radiative decays of quarkonia

- $\Gamma(V \to hadrons)$
- $\Gamma(V \to \gamma + X)$, $V = \Upsilon$, J/Ψ
- measure α_s and test perturbative QCD

(a) consistency of α_s measurements at m_Υ and $m_{J/\Psi}$

(b) understand photon spectrum in $V \to \gamma + X$

photon spectrum at $z(\equiv 2E_\gamma/W) \to 1$ (signal of nonperturbative QCD)



$\to$ perturbative QCD

$\to$ nonperturbative QCD

One possible explanation: parametrize nonperturbative contributions in terms of an effective gluon mass (M_g)

Parisi and Petronzio, PLB94(80)51; Consoli and Field, PRD49(94)1293; Field, NPB54A(97)247, JPG23(97)41

optimal values:

$J/\Psi \to M_g \sim 0.66$ GeV ; $\Upsilon \to M_g \sim 1.2$ GeV

Dynamical gluon mass?

Nonperturbative solution of Schwinger-Dyson equations for the gluon propagator (Cornwall, PRD26 (82) 1453)

$$D(P_E^2) \sim \frac{1}{P_E^2 + M_g^2(P_E^2)}$$

Lattice results $->$ an infrared finite propagator (Leinweber et al., hep-lat/0002020 - other possibilities... $1/P_E^4$ ruled out)

One expression for the dynamical gluon mass:
E. Gorbar and A. Natale, Phys.Rev. D61(2000)054012

$$M_g^2(P_E^2) = m_g^2 \theta(m_g^2 - P_E^2) + \frac{m_g^4}{P_E^2}\theta(P_E^2 - m_g^2)$$

with

$$m_g^2 \equiv \left(\frac{34 N \pi^2}{9(N^2-1)} < \frac{\alpha_s}{\pi} G^{\mu\nu} G_{\mu\nu} > \right)^{1/2}$$

consitent with OPE (Lavelle, PRD44(91)R26)

$$m_g \sim 0.64 \pm 0.20 \text{ GeV}$$

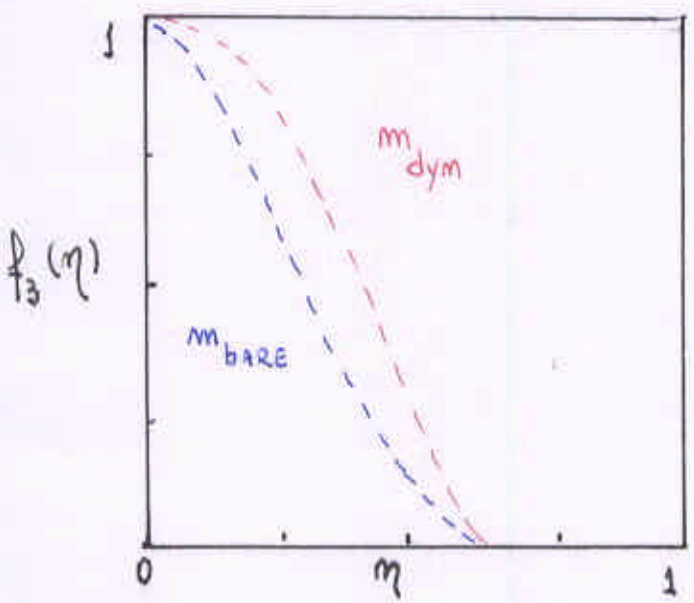
Gluon mass corrections in heavy quarkonia decays

A. Mihara and A. Natale, Phys.Lett.B482 (2000) 378

$R_V = \frac{\Gamma(V \to ggg)}{\Gamma(V \to ee)} \to + \; gluon \; mass \to f_3(\eta) R_V$

where $\eta \equiv \frac{2m_g}{M_V}$

$$f_3(\eta) = \frac{\Gamma(V \to ggg)|_{m_g}}{\Gamma(V \to ggg)|_{m_g=0}}$$



$$f_3(\eta_{M_\Upsilon}) \sim 0.94 \quad , \quad f_3(\eta_{M_{J/\Psi}}) \sim 0.47$$

Results

$\Gamma(\Upsilon \to hadrons)$ is not modified by a dynamical gluon mass. Change in $\Gamma(J/\Psi \to hadrons)$ is consitent with the prediction of Consoli and Field.

Photon spectrum in $J/\Psi \to \gamma + X$ at $z_\gamma \to 1$ is totally explained by the gluon mass.

Photon spectrum in $\Upsilon \to \gamma + X$? (dynamical gluon mass plus soft gluon emission ?)

Dynamical gluon mass also affects the running of α_s at small momentum

$$\alpha_s(Q^2) \to \frac{12\pi}{(11N-2n_f)\ln[(Q^2+\xi m_g^2)/\Lambda^2]}$$

where $\xi \sim 4$. $(\alpha_s^{m_g=0}/\alpha_s^{m_g})$ is a factor 1.6 at the scale m_c. $\alpha_s(m_b) \leftrightarrow \alpha_s(m_c)$?