Hadro-Charmonium

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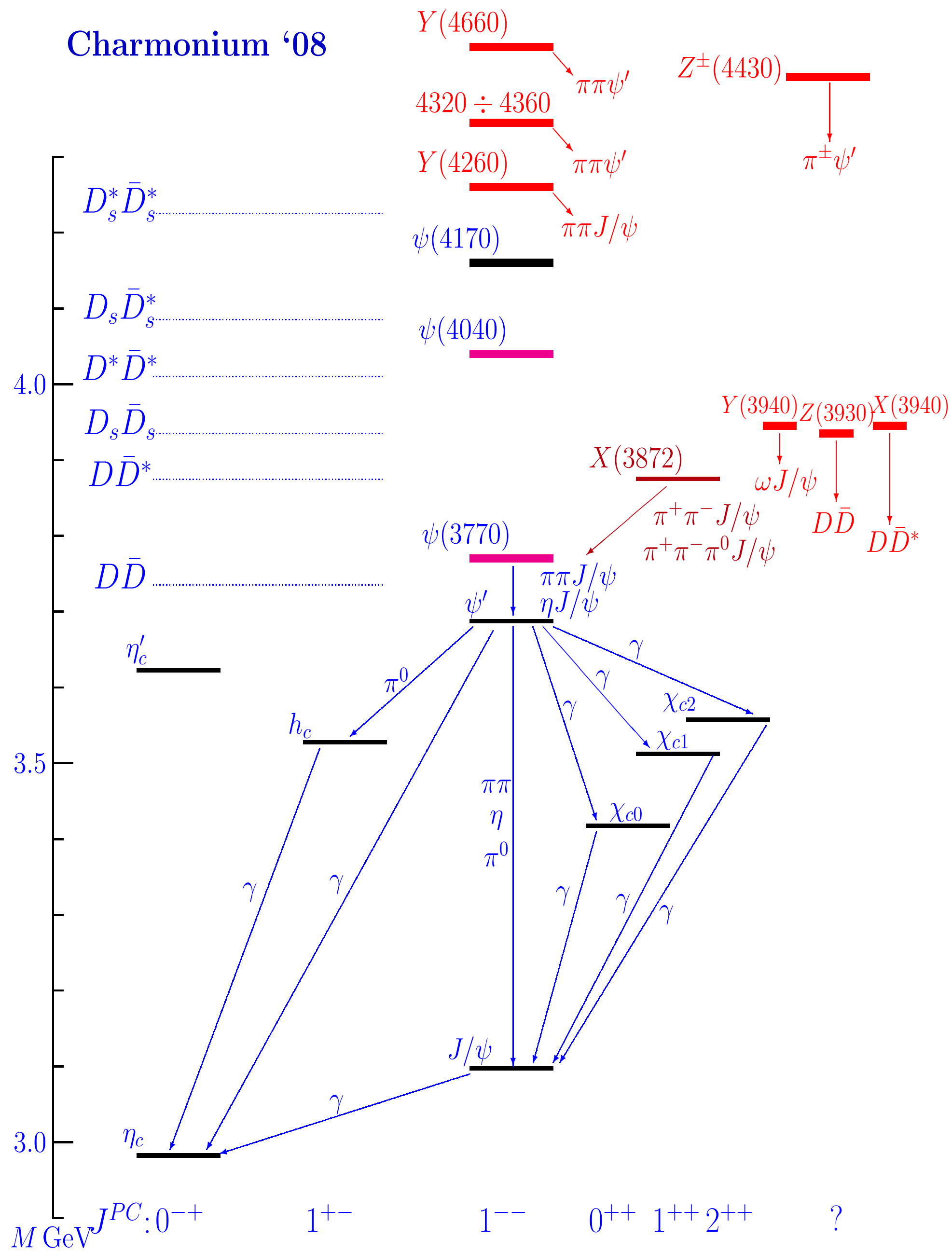
arXiv: 0803.2224 SD, M.B. Voloshin
arXiv: 0804.2244 SD, M.B. Voloshin, A. Gorsky



X, Y, Z ...

- **X(3872)**

  molecule (?)

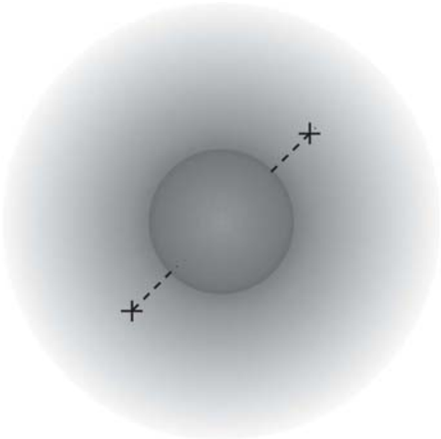
- **X(3940), Y(3940), Z(3930)**

  charmonium (?)

- **Y(4.26), Y(4.32-4.36), Y(4.66)**
- **Z(4.43)**

  hadro-charmonium (???)

Hadro-Charmonium



$$H_{eff} = -\frac{1}{2}\alpha^{(\psi)} E_i^a E_i^a$$

Schwartz inequality: $\alpha^{(J/\psi)}\alpha^{(\psi')} \geq \left|\alpha^{(\psi\psi')}\right|^2$

$\left|\alpha^{(\psi\psi')}\right| \approx 2\ GeV^{-3}$ is known from $\psi' \to \pi^+\pi^- J/\psi$

$$\theta_\mu^\mu = -\frac{9}{32\pi^2} F_{\mu\nu}^a F^{a\ \mu\nu} = \frac{9}{16\pi^2}(E_i^a E_i^a - B_i^a B_i^a)$$

$$\left\langle X \left| \theta_\mu^\mu(\vec{q}=0) \right| X \right\rangle = M_X$$

$$\left\langle X \left| H_{eff} \right| X \right\rangle \leq -\frac{8\pi^2}{9}\alpha^{(\psi)} M_X$$

$$\int V(\vec{x})\ d^3x \leq \frac{8\pi^2}{9}\alpha^{(\psi)} M_X$$

$$\int E_k d^3x \propto \frac{R}{\overline{\overline{M}}}$$

$$\alpha^{(\psi)} \frac{M_X \overline{M}}{R} \geq C$$

bag model: $R \propto M^{1/3}$

AdS/QCD : $R \propto M$

‘ square wall ’ potential $\alpha^{(\psi)} \frac{M_X \overline{M}}{R} \geq \frac{3\pi}{16}$

$M_X = 1\ GeV \Rightarrow R \leq 0.5\ fm$

$M_X = 2\ GeV \Rightarrow R \leq 1.8\ fm$

Holographic Hadro-Quarkonium

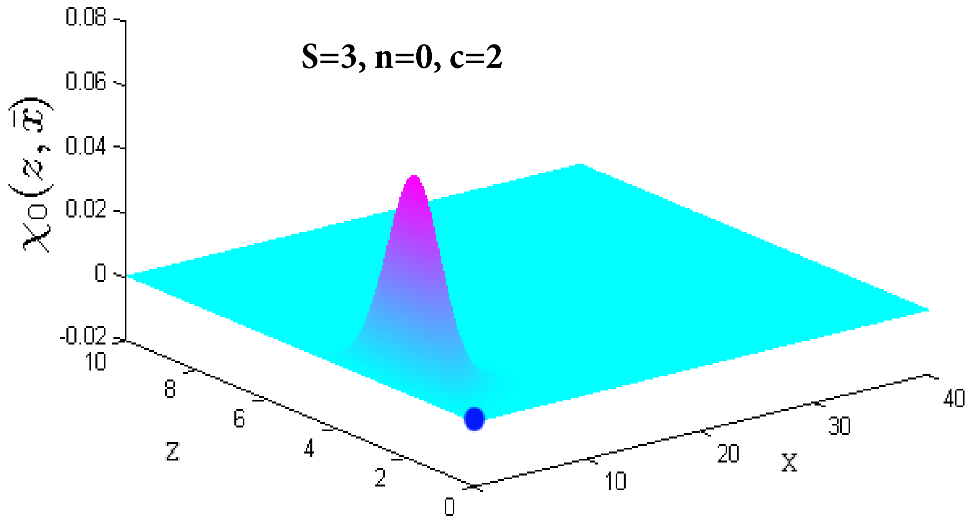
$$\left[-\Delta_x - \frac{\partial^2}{\partial z^2} + z^2 + 2S - 2 + \frac{S^2 - 1/4}{z^2} + V(z,\vec{x})\right] \chi_n(z,\vec{x}) = \omega_n^2 \chi_n(z,\vec{x})$$

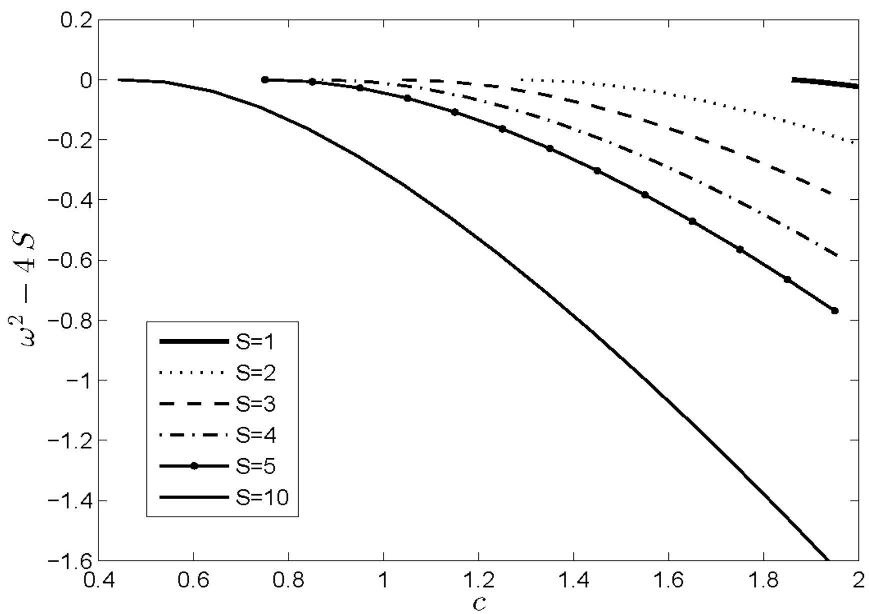
$$c = \frac{8\pi^2}{9} \alpha^{(Q\bar{Q})} \sigma^{3/2}$$

$$V(z,\vec{x}) = -c\ z^6 \int_0^\infty d\tau \left(\frac{1}{2\pi\tau}\right)^{3/2} \exp\left(-\frac{x^2}{2\tau}\right) \frac{e^{-\tau}}{\sinh^3\tau} \exp\left(-\frac{z^2}{2}\frac{e^{-\tau}}{\sinh\tau}\right)$$

$$\sigma \approx m_\rho^2 / 4 \approx 0.15\ GeV^2$$

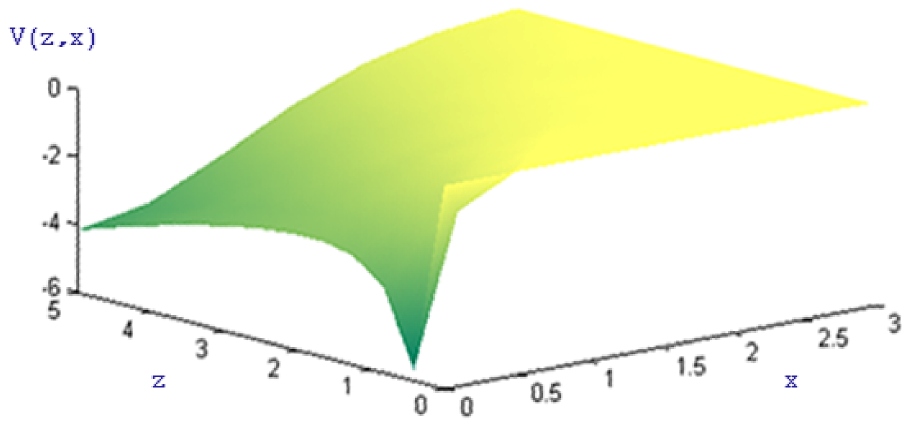
$\alpha^{(\psi\psi')} \approx 2\ GeV^{-3}$ $\quad c \approx 1$ $\quad$ binding at $S \geq 4$

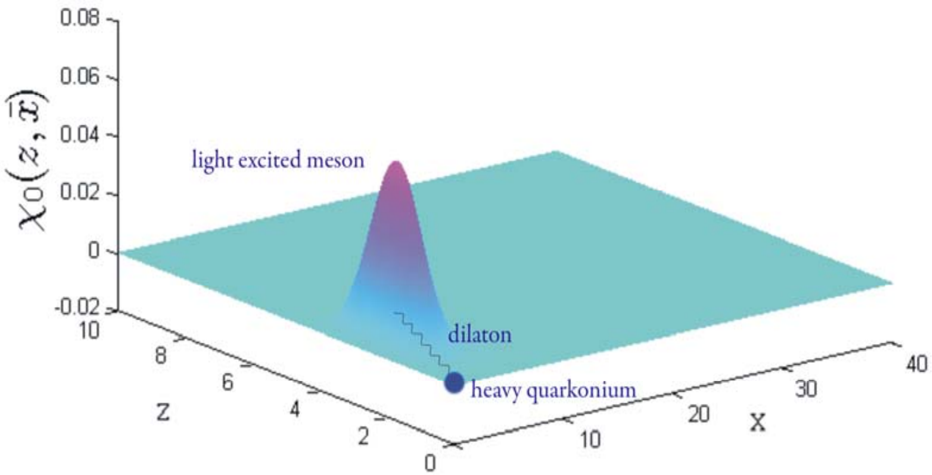




If such interpretation of Y’s and Z has anything to do with reality, there should be

- bound states of J/ψ and ψ' with light nuclei, or even a proton and/or deutron
- resonances containing χ_{cJ} charmonium, i.e. χ_{cJ} +pion(s)
- resonances containing excited bottomonium, $\chi_{bJ}(2P)$, $\Upsilon(3S)$, $\Upsilon(1D)$ in the mass range 11 – 11.5 GeV


V(z,x)
z
x


$\chi_0(z,\bar{x})$
light excited meson
dilaton
heavy quarkonium
z
x