Mass spectra of B_c Meson with energy dependent potential

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Introduction: The B_c meson provide a unique window into heavy quark dynamics. Both in mass and in size, this meson with beauty and charm is intermediate in between the $c\bar{c}$ and $b\bar{b}$ systems. The mass of B_c meson is one of the numbers of states lying below the threshold for emission of B and D mesons. The B_c and B_c* are the ground state and the first excited state of the binding system $b\bar{c}$ quarkonium system. In the present work we have estimated the masses of $b\bar{c}$ system using energy dependent potential in the non-relativistic frame work of quantum mechanics. This theory was already applied to the charmonium and bottonium in our previous paper [1]. The spectroscopic parameters of energy dependent potential and for $b\bar{c}$ system is also calculated.

In order to calculate the mesonic energy levels we obtain the energy eigen values by solving the Schrodinger equation in the center - of - mass system as

$$\left[-\frac{\hbar^2}{2\mu}\overrightarrow{\nabla^2}+V(r,E_{n,l})\right]\psi_{n,l,m}(r)=E_{n,l}\psi_{n,l,m}(r)\ , \qquad \ldots\ldots\ldots\ldots\ (1)$$

where the reduced mass μ in terms of quark mass m_q and antiquark mass $m_{\bar{q}}$ is

$$\mu=\frac{m_q m_{\bar{q}}}{m_q+m_{\bar{q}}}\ .$$

and chosen spherically symmetric potential

$$V(r,E_{n,l})=\frac{1}{2}m\omega^2r^2(1+\gamma E_{n,l})+\frac{g}{r^2} \qquad \ldots\ldots\ldots\ldots\ (2)$$

where ω, γ and g are constants.

$$E_{n,l}=-\frac{1}{8}a^2\omega^2\gamma+\frac{a\omega}{8}\sqrt{a^2\omega^2\gamma^2+16}\ , \qquad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where $a=4n-2+\sqrt{(2l+1)^2+8\mu g}$

$E_{n,l}$ are the eigen energies classified by principal and angular quantum numbers $l\leq (n-1)$. Finally the quark mass is connected to the physical mass as

$M_{(qq)}=2m_q+E_{1s.}$

We obtain potential parameters by solving radial Schrödinger equation for eigen values (3) with and without energy dependent potential. These nonlinear simultaneous equations of eigen value are solved numerically by MATLAB 7.0. Since negative root of γ can only compress spectrum, we consider it as negative. As the experimental data of low lying states are not known, we have fitted the parameters from the earlier theoretical estimates [2] for $b\bar{c}$ system. The reduced mass is obtained from the data m_c=1.5 GeV and m_b= 4.5 GeV. Obtained parameters for energy dependent case are shown in table 1. Corresponding potential curves for energy dependent and independent case is plotted in figure 1. We further show radial energy splittings for S waves. Position of different E_{nS} states with respect to E_{1S} are shown in table 2. It is observed that the E_{nS}-E_{1S} increases slowly with principal quantum number. This increase is less rapid for energy dependent potential, showing saturation effect as compared to energy independent case (γ =0).

Conclusion: Predicated masses of $b\bar{c}$ system for lowest S, P and D waves with respect to E_{1s} with and without energy dependent potential are plotted in figure 2. Numerical values of mass spectra for S, P and D states are in agreement with those calculated by various methods by other author [2]. Once the experimental low lying states of the $b\bar{c}$ spectra becomes available one may be able to sharpen analysis by adjusting parameters and then predicting more accurate values of $b\bar{c}$ properties.

Table 1: Spectroscopic parameters calculated by equation

ω (fm^{-1})	γ (GeV^{-1})	g (GeV^{-1})
0.176	-0.056	-0.115

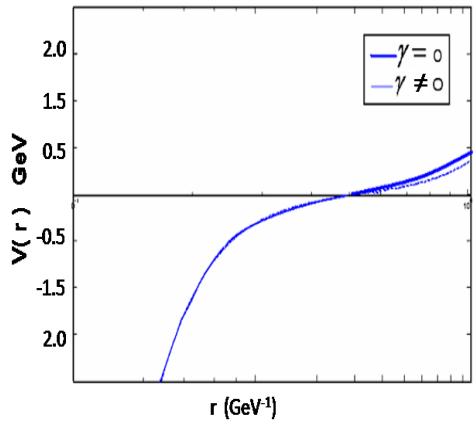

Figure 1 : Potential curve for $b\bar{c}$ quarkonium system plotted for energy dependent and independent case.

Table2 :

$E_{n,s}$–$E_{1,s}$ between various radial excitation for S wave for $b\bar{c}$ system

(In GeV)	γ=0	γ ≠0
E_{4S} -E_{1S}	1.20	1.16
E_{5S} -E_{1S}	1.54	1.47
E_{6S} -E_{1S}	1.87	1.86

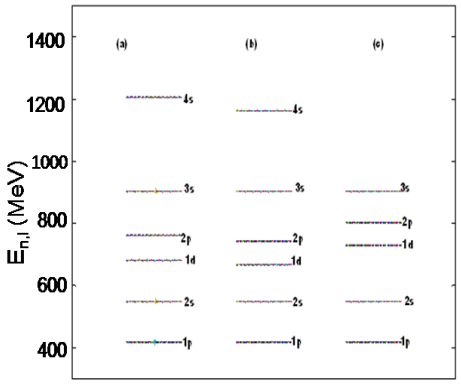

Figure 2 : Mass spectrum of ($b\bar{c}$) system with respect to ground state (E_{1s}) with (a) γ =0 (b) $\gamma \neq 0$ (c) calculated by [Ger95]. The levels with asterisk are used as input data in the parameter fitting.

Reference

[1]. P.Gupta et al., DAE Int. Symp. on Nucl.Phys. **54**, 518 (2009)

[2]. S.S. Gershein et al., Phys. Rev. D **51,** 3613 (1995).