Mass Spectra and Magnetic Moment of $\Xi_b^{'}$ baryon

Amee Kakadiya* and Ajay Kumar Rai
[1]*Department of Physics, Sardar Vallabhbhai National Institute of Technology, Surat-395007, Gujarat, INDIA*

Introduction

The Ξ_b baryons contain one u/d quark, one s quark and one b quark. There are three states of Ξ_b baryon: $\Xi_b^0(usb)$, $\Xi_b^-(dsb)$ and $\Xi_b^{'-}(dsb)$. (Though the quark contains are same, Ξ_b^- and $\Xi_b^{'-}$ are different.) Three such Ξ_b isodoublets that are neither orbitally nor radially excited are expected to exist, and can be categorized by the spin j of the us or ds diquark and the spin-parity J^p of the baryon: one with $j = 0$ and $J^p = \frac{1}{2}^+$, one with $j = 1$ and $J^p = \frac{1}{2}^+$ and one with $j = 1$ and $J^p = \frac{3}{2}^+$. This follows the same pattern as the well-known Ξ_c states [2], and we therefore refer to these three isodoublets as the Ξ_b, the $\Xi_b^{'}$ and Ξ_b^*.

The spin-antisymmetric $J^p = \frac{1}{2}^+$ state, observed by multiple experiments [3–5], is the lightest and therefore decays through the weak interaction. The others should decay predominantly strongly through a P-wave pion transition ($\Xi_b^{',*} \to \Xi_b\pi$) if their masses are above the kinematic threshold for such a decay; otherwise they should decay electromagnetically ($\Xi_b^{',*} \to \Xi_b\gamma$) [5]. These states are comes in antisymmetric anti-triplet of $S(U)3$ flavour symmetry.

In present work, we have predicted the masses of $1S$, $1P$ and $1D$ states of $\Xi_b^{'}$ baryon by using Hypercentral Constituent Quark Model (hCQM) and screening potential is employed as the confining potential with the color-Coulomb potential. We have also calculated the ground state magnetic moment of the $\Xi_b^{'}$ baryon.

*Electronic address: ameekakadiya@gmail.com

Theretical Framework

Jacobi coordinates are employed to describe the inter-quark dynamics which are [6, 7],

$$\vec{\rho} = \frac{\vec{r_1} - \vec{r_2}}{\sqrt{2}} \quad and \quad \vec{\lambda} = \frac{\vec{r_1} + \vec{r_2} - 2\vec{r_3}}{\sqrt{6}}. \tag{1}$$

The Hamiltonian of the three quark bound system is given by [8],

$$H = \frac{P^2}{2m} + V(x) \tag{2}$$

Here, P is conjugate momentum, m is reduced mass [8–15] for Jacobi coordinates and $V(x)$ is non-relativistic interaction potential inside the baryonic system. The constituent quark masses are: $m_u = 0.350GeV, m_d = 0.350GeV, m_s = 0.500GeV, m_b = 4.670GeV$.

The screened potential is employed as a confining potential with the color-Coulomb potential [16].

$$V_{conf}(x) = a\left(\frac{1 - e^{-\mu x}}{\mu}\right) \tag{3}$$

where, a is the string tension and the constant μ is the the screening factor. And the color-Coulomb potential is,

$$V_{Col}(x) = \frac{\tau}{x} \tag{4}$$

where,x indicates the inter-quark separation, the hyper-Coulomb strength $\tau = -\frac{2}{3}\alpha_s$ ($\frac{2}{3}$ is color factor for baryon), the parameter α_s corresponds to the strong running coupling constant, which is,

$$\alpha_s = \frac{\alpha_s(\mu_0)}{1 + \left(\frac{33-2n_f}{12\pi}\right)\alpha_s(\mu_0) ln\left(\frac{m_1+m_2+m_3}{\mu_0}\right)} \tag{5}$$

For present calculation, $\alpha_s = 0.7$, $\mu_0 = 1$ GeV and $n_f = 5$ (the number of active quark flavor contributing in a quark-gloun loops effectively). The quantity $(33 - 2n_f)$ is must be greater than zero, so n_f is never larger than six. After defining the confining potential and other parameters, the Schrödinger equation [17] of the $\Xi_b^{'}$ baryon system can be solved using Mathematica notebook [18].

Mass Spectra

TABLE I: Masses of radial and orbital states of $\Xi_b^{'}$ baryon (in GeV).

state	J^p	Present	[1]	[19]	[20]	[21]
$1S$	$\frac{1}{2}^+$	5.935	5.935		5.935 ± 0.5	
$1P$	$\frac{3}{2}^-$	6.323		6.233		6.142
$1D$	$\frac{5}{2}^+$	6.371		6.459		

The ground state ($1S$) mass of $\Xi_b^{'}$ baryon is fixed as per PDG data [1]. Further states masses are predicted using Mathematica notebook program [18]. Our mass predictions for ground state and orbital states are in good agreement with the references [19–21]. Hence, we will extend this scheme to predict the masses of further radial and orbital excited states.

Magnetic Moment

Magnetic moment is the intrinsic property of the baryon caused by spin of its constituents. Magnetic moment of the ground state of the singly heavy bottom-strange baryon can be obtained by using effective mass of ground state, individual charge and spin-flavour arrangement of the constituent quarks [9, 22]. The details of this study will be presented during conference.

TABLE II: Magnetic moment of ground state of $\Xi_b^{'}$ baryon. (in MeV)

Baryon	J^p	Present
$\Xi_b^{'-}$	$\frac{1}{2}^+$	-0.941
$\Xi_b^{*'-}$	$\frac{3}{2}^+$	-1.498

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