Beauty baryons ($bqq, q \in u, d, s$) using quark-diquark model

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Introduction

Recent experimental observations of excited charmed baryons by Belle and Babar collaborations [1, 2] and new beauty baryon states like $\Sigma_b^{\pm}$, $\Sigma_b^{*\pm}$ and Ξ_b^- by CDF [3, 4] and Ξ_b^- by D0 have generated an increasing interest on heavy baryon spectroscopy. It is striking that baryons containing one or two heavy charm or beauty flavour are important systems to study the quark-diquark structure of baryons and to understand the dynamics of QCD at hadronic scale [5]. The copious production of heavy quarks at LEP, Fermilab Tevatron, CERN and B factories, opened up rich spectroscopic study of heavy hadrons. We report here the spectra of $bqq(q \in u, d, s)$ systems using coulomb plus power potential by considering the two light quarks as the diquark states.

Methodology

The Hamiltonian of the baryon, in the diquark model, can be written in terms of diquark Hamiltonian plus quark-diquark Hamiltonian as [6]

$$H = H_{jk} + H_{i,jk} \tag{1}$$

The internal motion of the diquark(jk) is described by

$$H_d = H_{jk} = \frac{p^2}{2m_{jk}} + V_{jk}(r_{jk}) \tag{2}$$

where, p is the relative momentum of the quarks within the diquark. The Hamiltonian of the relative motion of the diquark(jk) and the third quark(i) is given by

$$H_{i,d} = H_{i,jk} = \frac{q^2}{2m_{i,jk}} + V_{i,jk}(r_{id}) \tag{3}$$

where, q is the relative momentum between the diquark and the third quark, the reduced mass of the diquark (m_{jk}) and quark-diquark system ($m_{i,jk}$) are defined as $m_{jk} = \frac{m_j m_k}{m_j+m_k}$ and $m_{i,jk} = \frac{m_i(m_j+m_k)}{m_1+m_2+m_3}$.
Here, the diquark potential and quark-diquark potential are assumed to be of the same form given by

$$V_{jk} = -\frac{2}{3}\alpha_s \frac{1}{r_{jk}} + b\ r_{jk}^{\nu} \tag{4}$$

and

$$V_{i,jk} = -\frac{4}{3}\alpha_s \frac{1}{r_{id}} + b\ r_{id} \tag{5}$$

where, r_{id} is the quark-diquark separation distance, α_s being the running strong coupling constant, b is the model parameter corresponding to the confining part of the potential, which is assumed to be same for the di-quark interaction as well as between the quark-diquark interaction.
The numerical approach using the Runge-Kutta method in a mathematica note book has been used to solve the Schrodinger equation correspond to the Hamiltonian as given in Eq.1. The parameters are fixed to yield the spin average mass as well as the hyperfine spiltting of the ground states. The mass splitting has been studied for different choices of the quark mass parameter, m_b for each case of the potential index ν. the results for bdd and bss systems are shown in fig.1and 2 respectively.

Conclusion

We have employed a simple non-relativistic approach to study the mass and the hyperfine splitting of the single heavy flavour baryons with coulomb plus power potential. The hyperfine splitting of the ground state has been

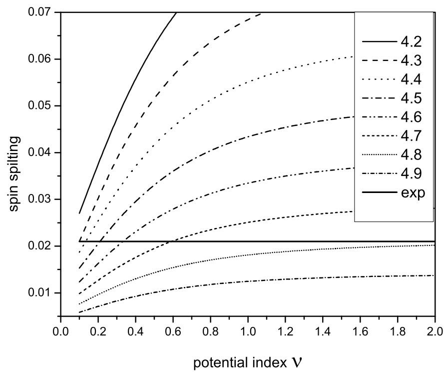

FIG. 1: Hyperfine Splitting for different range of the m_b vs potential index ν for bdd system.

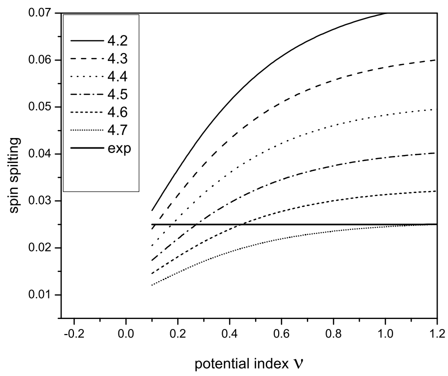

FIG. 2: Hyperfine Splitting for different range of the m_b vs potential index ν for bss system.

studied with different choices of the potential index, ν as well as with different choices of the heavy quark mass parameter. The behaviors are shown in fig.1and 2 for bdd and bss systems. It is found that the heavy quark mass parameter plays a decisive role in the mass splitting of the ground states. The value of the beauty quark mass parameter, m_b is found to be lie in the range of 4.3 GeV to 4.7 GeV for the choices of ν from 0.1 to 0.7 in the case of bdd system and for the choices of ν for 0.1 to 1.1 in the case of bss systems.

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