Masses of Σ_c Σ_c and Σ_c^* Σ_c^* dibaryonic systems

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Introduction

Dealing with some multiquark states using the traditional quark model is challenging. Several exotic states have been seen experimentally in recent years [1, 2]. Many possible exotic states, such as molecules, glueballs, hybrids, tetraquarks, pentaquarks, and hexaquarks, are suggested in the theoretical article [3–13]. The most widely accepted picture among them is likely the hadronic molecular picture because most of these unconventional states are seen in proximity to the mass thresholds of typical hadron couples.

We have calculated the masses of singly charmed baryons in our previous study[14], combination of two heavy singly charm baryons- dibaryons are our current interest. In the present situation, there have yet to be any newly found heavy six quark states. Due to the high energy needed and the poor generation of charmed baryons, experimental searches for dibaryons containing charm quarks are difficult. There have been lot of theoretical studies that try to explain the existence of dibaryons within the frame work of lattice QCD [15, 16], "one boson" exchange (OBE) potential [17], potential models [18, 19], and dispersion relation technique [20], quark delocalization color screening model [22], Heavy quark spin symmetry [23].

In this paper, we examine potential dibaryonic molcules Σ_c Σ_c and Σ_c^* Σ_c^* in the open charm sector. We have approximated the dibaryon as an S-wave OBE plus screen "Yukawa-like" potential and predict the masses of molecule in its relativistics S-wave state.

Theoretical Framework

The hydrogen-like trial wave function is employed in the variational technique to calculate the mass spectra of the dihadronic systems. We employ the OBE plus screen Yukwa-like potential to find the S-wave spectra. The dihadronic molecule's Hamiltonian is provided by [7, 9]

$$H = \sqrt{P^2 + m_{h_1}^2} + \sqrt{P^2 + m_{h_2}^2} + V_{hh} \quad (1)$$

The interaction potential is given by,

$$V_{hh} = V_{\text{OBE}} + V_Y \quad (2)$$

where $V_Y(r_{db})$ is the screen Yukawa-like potential and V_{OBE} is S-wave OBE potential. The screen Yukawa-like potential is expressed as

$$V_Y \;=\; -\frac{k_{mol}}{r_{db}} e^{\frac{-c^2 r_{db}^2}{2}} \quad (3)$$

where, c is a screen fitting parameter of the potential and k_{mol} is the residual running coupling constant. The net S-wave OBE potential with finite size effect can be expressed as [24]

$$V_{OBE} = V_{ps} + V_s + V_v \quad (4)$$

TABLE I: The threshold mass, reduced mass and k_{mol} of systems are given.

System	Threshold mass (in GeV)	Reduced mass (in GeV)	k_{mol}
Σ_c Σ_c	4.907	1.226	0.2431
Σ_c^* Σ_c^*	5.037	1.259	0.2412

Results and discussions

In this study, we try to systematically examine the J^P values of $\frac{1}{2}^+$ and $\frac{3}{2}^+$, which are the single-flavored dibaryon bound states,

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*Electronic address: `zalak.physics@gmail.com` for $\Sigma_c\ \Sigma_c$. For the ground state computations, the various (I,S) combinations are taken into account. Among them, our computations forbidden the channels (I,S) = (0,0), (2,0), (1,1), (0,3) and (2,3). The allowed isospin-spin channels are (I,S)=(0,1), (1,0) and (2,1). in which, (0,1), (1,0) are appeared as very shallow bound state while (2,1) channel is found unbound.

TABLE II: Masses of the system with available literature(in GeV).

System	[21]	[22]	[23]
$\Sigma_c\ \Sigma_c$	4.754	4.925	4.906
$\Sigma_c^*\ \Sigma_c^*$	4.967	4.983	5.023

Our result for the $\Sigma_c^*\ \Sigma_c^*$ bound state shown in Tables[I-II] are in agreement with other theoretical models. We may calculate the baryon-antibaryon dibaryonic systems in our future work.

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