$\Omega_c - \Omega_c$: Possible di-baryonic molecule

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Introduction

Search for hadronic molecule is effortful experimental and theoretical task in the physics of strong interaction where under lying theory of quantum Chromodynamics (QCD) has been dispute for decades by the apparent absence of multi-quark states. In the non-strange sector, the deuteron is the only known experimentally candidate as a hadronic molecule. Apart from deuteron, we are still searching other strong hadronic molecular candidate. There are large numbers of the hadronic molecules have been predicted in the various theoretical approaches in which H-dibaryon (in strange sector) is the most promising candidate with deep binding [1–8].

In the present study, we study the possible $\Omega_c - \Omega_c$ di-baronic molecule in the open charm sector. Here, we have approximated the interaction potential of the di-baryon as a s-wave One Boson Exchange Potential plus screen Yukawa like potential. We predict the binding energy, mass and root mean square radius of $\Omega_c - \Omega_c$ molecule in its relative s-wave state.

Theoretical Framework

We have determined the S-wave ground state energy of the di-hadronic molecule in the Ritz variational scheme. The two body di-hadronic Hamiltonian can be expressed as [9–14]

$$H = \sqrt{P^2 + m_1^2} + \sqrt{P^2 + m_2^2} + V_{hh}(r_{12}) \quad (1)$$

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Here, m_1 and m_2 are the masses of the two constituent hadrons while P is the relative momentum of the two particle system. Whereas, $V_{hh}(r_{12})$ is the interaction potential between two hadrons, namely

$$V_{hh}(r_{12}) = -\frac{\alpha_s}{r_{12}} e^{\frac{-c^2 r_{12}^2}{2}} + V_{OBE} \quad (2)$$

where α_s is the residual running coupluing constant and c is the screen fitting parameter. The first term in the above equation is the attractive screen type potential while V_{OBE} is usual S-wave One Boson Exchange Potential [8]. In the variational scheme, we have used the Hydrogenic trial wave function, namely

$$R_{nl}(r) = \left(\frac{\mu^3 (n-l-1)!}{2n(n+l)^3!}\right)^{\frac{1}{2}} (\mu r_{12})^l \; e^{\frac{-\mu r_{12}}{2}} L_{n-l-1}^{2l+1}(\mu r_{12}) \quad (3)$$

where $L_{n-l-1}^{2l+1}(\mu r_{12})$ is the Laguerre polynomial and μ is the variational parameter. In the variational approach, the ground state energy of the low-lying system are calculated by obtaining the expectation value of the Hamiltonian. The variational parameter (μ) is determined for each state by using the Virial theorem

$$H\psi = E\psi$$
$$and$$
$$\langle K.E. \rangle = \frac{1}{2} \left\langle \frac{r_{12} dV(r_{12})}{dr_{12}} \right\rangle \quad (4)$$

Result and discussion

In the variational approach, we have calculated the mass spectra of possible $\Omega_c - \Omega_c$ di-bariyonic molecular state. The interaction potential has used as the screen Yukawa-like

plus s-wave OBE potential. Pion can not couple with Ω_c, hence, in the case of $\Omega_c - \Omega_c$ pion exchange can not be applied. Thus, we have used other meson exchange in the present study. The possible quantum number of the $\Omega_c - \Omega_c$ are (I,S)=(0,0) and (I,S)=(0,1) where I and S are isospin and spin quantum number respectively. In our calculation, the binding energy, mass and root mean square radius of the molecular $\Omega_c - \Omega_c$ with quantum number (I,S)=(0,0) and $J^P = 0^+$ are found

$$\begin{aligned} BE_{\Omega_c\Omega_c} &\cong 8.51 MeV \\ M_{\Omega_c\Omega_c} &\cong 5.381 GeV \\ \sqrt{r^2} &\cong 1.1 fm \end{aligned}$$

while with quantum number (I,S)=(0,1) and $J^P = 1^+$ are found

$$\begin{aligned} BE_{\Omega_c\Omega_c} &\cong 8.67 MeV \\ M_{\Omega_c\Omega_c} &\cong 5.381 GeV \\ \sqrt{r^2} &\cong 1.1 fm \end{aligned}$$

In Ref. [3], Ning Lee et.al., has also predicted the bound state of the $\Omega_c - \Omega_c$, whereas our predicted binding energy and mass are in agreement with [3] and suggested the $\Omega_c - \Omega_c$ as a hadronic molecule.

The detail of this study will be presented in the conference.

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