Possible existence of charmonium-nucleus bound states

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One of the important topics in charmonium($c\bar{c}$) physics is to study ($c\bar{c}$)−nucleon(N) interaction which is dominated by QCD color van der Waals force (multiple gluon exchange). The role of gluon (and therefore QCD) as hadronic interaction can be studied in this system. Another important topic is to discuss the possible existence of ($c\bar{c}$)−nucleus bound states due to the weakly attractive nature of the QCD color van der Waals force. This is a novel hadronic state which is bound mainly by gluonic interaction. Precise study of ($c\bar{c}$)−nucleus bound states in both theoretical and experimental research could figure out $(c\bar{c}) - N$ interaction without scattering experiment which is difficult to perform. For these purposes, previous researches[1] have studied the $(c\bar{c})-N$ potential and the binding energies of ($c\bar{c}$)-nucleus for several nuclei, although the results are not in agreement with each other.

Along this line, first we study $J/\psi - NN$ three-body system by GEM[2]. We employ an effective (single-)Gaussian potential for $J/\psi - N$ interaction and calculate J/ψ−deuteron binding energy B for various values of the potential strength. Then we obtain the relation between B and the J/ψ−N scattering length $a_{J/\psi-N}$. The result shows that $a_{J/\psi-N} \leq -0.95$ fm is needed to form a bound state. Next we study J/ψ−^{4}He system. Since ^{4}He is a deep bound state, we treat ^{4}He as an α cluster and use $J/\psi-\alpha$ folding potential with the nucleon density distribution of ^{4}He with the center of mass correction(CMC). The result shows that $a_{J/\psi-N} \leq -0.24$ fm is needed to form a bound state. Finally, we study J/ψ−^{8}Be system as $J/\psi - \alpha - \alpha$ three-body system, using the $J/\psi - \alpha$ folding potential with CMC as before. The result shows that $a_{J/\psi-N} \leq -0.16$ fm is needed to form a bound state. We have also checked that the results are not sensitive to the form (Gaussian or Yukawa-type) and the range of the $J/\psi - N$ potential[3]. The current lattice QCD data $a_{J/\psi-N} \sim -0.35$ fm[4] corresponds to $B \sim 0.5$ and 2 MeV for J/ψ−^{4}He and J/ψ−^{8}Be, respectively. Thus, we conclude that charmonium J/ψ will form bound states with nuclei of $A \geq 4$, supposing that the current lattice QCD evaluation of $a_{J/\psi-N}$ is reliable. In the conference we will report more details including density distribution and glue like role of J/ψ.

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