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Lattice study on a tetra-quark state T_{bb} in the HALQCD method

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We study a doubly-bottomed tetra-quark state $(bb\bar{u}\bar{d})$ with quantum number $I(J^P) = 0(1^+)$, denoted by T_{bb} , in lattice QCD with the NRQCD quark action for b quarks.

Employing (2 + 1)-flavor gauge configurations at $a \approx 0.09$ {fm} on $32^3 \times 64$ lattices, we have extracted the coupled channel HAL QCD potential between $\bar{B}\bar{B}^*$ and $\bar{B}^*\bar{B}^*$, which predicts an existence of a bound T_{bb} below the $\bar{B}\bar{B}^*$ threshold.

By extrapolating results at $m_{\pi} \approx 410, 570, 700$ {MeV} to the physical pion mass $m_{\pi} \approx 140$ {MeV}, we obtain a biding energy with its statistical error as $E_{\text{binding}}^{(\text{single})} = 155(17)$ MeV and $E_{\text{binding}}^{(\text{coupled})} = 83(10)$ MeV, where "coupled" means that effects due to virtual $\bar{B}^*\bar{B}^*$ states are included through the coupled channel potential, while only a potential for a single $\bar{B}\bar{B}^*$ channel is used in the analysis for "single".

A comparison shows that the effect from virtual $\overline{B}^*\overline{B}^*$ states is quite sizable to the binding energy of T_{bb} . We estimate systematic errors to be ± 20 MeV at most, which are mainly caused by the NRQCD approximation for *b* quarks.

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