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The impact of quark many-body effects on exotic hadrons

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The constituent quark models successfully explain the features of the single hadrons. The hadron interactions are also well-reproduced. For example, the channel dependence of the short-range part of two-baryon interaction corresponds to those given by the Lattice QCD.

In this work, we investigate the exotic hadrons, $(q\bar{q})$-$(q\bar{q})$. The spin-dependent term of the one-gluon exchange force (CMI) has been well investigated and is known to be responsible for giving an attraction to form the exotic hadrons.
The most significant effect, however, comes from the internal structure in terms of the quark degrees of freedom. The effect of hadrons being composed of multiple quarks is incorporated into the present model as a spectroscopic factor (S-factor). This effect can be repulsive (because of the quark Pauli-blocking) or attractive (because of the many-body effect) and has strong channel dependence. The effect appears in the overlapping spacial region between the compact quark configuration and the two-hadron scattering states.

By using a quark-hadron hybrid model that includes both of the above effects, we investigate the T_{cc}.The T_{cc}, $\bar{u}\bar{d}cc$ $I(J^P)$=0(1^+), consists of two components: (A) cc spin-1 $\bar{u}\bar{d}$ spin-0 and (B) cc spin-0 $\bar{u}\bar{d}$ spin-1. Because of the symmetry, there is no cc spin-1 $\bar{u}\bar{d}$ spin-1 component with the isospin 0. For both of the components, the CMI is attractive, but their sizes are different. CMI in (A) is six times more attractive than in (B). On the other hand, the S-factor in (A) is repulsive, while it is attractive in (B). As a result of this cancellation, we found that without the long-range attraction from the pion exchange, the T_{cc} becomes a virtual state. Also, we found that T_{bb} is a deeply bound state because the S-factor effect reduces in a compact state.

Such a cancellation can also be seen in other exotic hadrons, such as the P_c. Our aim here is a comprehensive understanding of the mechanism to form the exotic hadrons.

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