Contribution ID: **63** Type: **not specified**

Heavy hadronic molecules with pion exchange and coupling to multiquarks

Tuesday, 9 March 2021 13:30 (30 minutes)

Recently exotic hadrons including a $c\bar{c}$ component have been reported in experimental researches. The exotic states cannot be explained by the ordinary hadron picture, namely a baryon as a three-quark state, and a meson as a quark-antiquark state, while a multiquark component would be dominated in their structure. Since the discovery of $X(3872)$ in 2003, the exotic mesons called X, Y, Z, appearing above the $D^{(*)}\bar{D}^{(*)}$ thresholds, have been investigated. As the exotic baryon states, the hidden-charm pentaquark P_c considered to be a $uudc\bar{c}$ state has attracted a lot of interest, which was reported by the LHCb collaboration. There have been many discussions about a structure of the P_c states such as the compact $uudc\bar{c}$ state, the meson-baryon hadronic molecules, triangle singularity. We investigate the P_c pentaquarks as a $\bar{D}^{(*)}\Lambda_c - \bar{D}^{(*)}\Sigma_c^{(*)}$ hadronic molecule coupling to a $qqqc\bar{c}$ compact core. The coupling to the core plays an short-range interaction ($5q$ potential) between the meson and baryon, generating an attraction. The relative strength for the meson-baryon channels is determined by the color-flavor-spin structure of the core states. In addition, the one pion exchange potential (OPEP) as a long-range interaction is introduced by the effective lagrangians satisfying the chiral and heavy quark spin symmetries. The OPEP has been known as a driving force to bind atomic nuclei, where the tensor term leading the coupled-channel effect generates a strong attraction. The mass degeneracy of heavy hadrons due to the heavy quark spin symmetry enhances the OPEP derived by the $\pi D^{(*)}\bar{D}^{(*)}$ and $\pi\Sigma_c^{(*)}\Sigma_c^{(*)}$ couplings. Our model can consistently explain the masses and widths of the P_c states reported by LHCb in 2019. The role of the interactions employed in this model is investigated, and we find that the structure of the energy level is determined by the $5q$ potential, while the decay width by the tensor term of the OPEP.

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