Research report: Decays of double charmed meson molecules

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The same formalism used for the X(3872) in [1, 2] is also applied to the $D^*_{(s)}\bar{D}^*_{(s)}$ system, where the vector-vector interaction is also given by a vector-exchange interaction evaluated from the hidden gauge lagrangian [3]. It generates dynamically molecular states of $D^*\bar{D}^*$ with masses close to their threshold, with properties similar to those of X(4160), Y(3940) and Z(3930).The interaction provided by the hidden gauge lagrangian for the vector - vector system, does not predict states in all sectors, only there is enough attraction to bind the system in the sectors $(C = 0; S = 0)$, $(C = 1; S = -1, 0, 1)$ and $(C = 2; S = 0, 1)$ [4]. In [4], some of the difficulties in the quark model do not exist in the molecular picture, like, for instance, the narrow states observed in the first excited state of D_s spectrum, can not be explained by the quark model. It is possible to obtain as dynamically generated states, the X(3872), from vector-pseudoscalar interaction, the XYZ and doubly charmed states, named here as "$R^+_{cc}(3970)$", "$S^{+(+)}_{cc}(4100)$", from the vector-vector interaction, by using very similar value of the free parameter, the subtraction constant or cutoff in the two-meson function loop [4]. Therefore, if the X(3872) and some of XYZ states are good candidates of meson-molecular states, we strongly expect that there are doubly charmed mesons. In this year we have performed an important study about the decay modes of the "$R^+_{cc}(3970)$" and "$S^{+(+)}_{cc}(4100)$". Because of a bosonic system, a $D^*D^*_{(s)}$ molecule can form a state of spin and parity $J^P = 1^+$ when they are dominated by an S-wave state. We have considered the possible decays of the $R^+_{cc}(3970)$, $S^+_{cc}(4100)$ and $S^{++}_{cc}(4100)$, which are essentially $D^0D^{*+}_{(s)}$, $D^{*0}D^+_{(s)}$ and $D^{*+}D^+_s$ and evaluated the partial decay widths. We obtain that the main source of these decays come from the decay of a $D^*_{(s)}$ meson into $D_{(s)}\pi$ or $D_{(s)}\gamma$. The total widths of the double charm molecules are 44 ± 12 MeV for the $R^+_{cc}(3970)$ and 24 ± 8 MeV for the $S^+_{cc}(4100)$ and $S^{++}_{cc}(4100)$. These decays are mediated by the exchange of one meson, vector or pseudoscalar, between the $D^*D^*_{(s)}$ pair of the molecule. The biggest width comes from ρ, π and ω exchange for the $R^+_{cc}(3970)$, and K^*, K, J/ψ exchange for the $S^{+(+)}_{cc}(4100)$. These mesons are a challenge for the experimentalist, since they are not $q\bar{q}$, have a pair of cc and they are double charged. How to produce these mesons is a difficult question. Up to now, the only observed double charmed particle is the Ξ^+_{cc}, by its decays, $\Lambda^+K^-\pi^+$ and pD^+K^- [6], however, the BABAR experiment didn't find evidence for a Ξ^+_{cc} in a search in $\Lambda^+_cK\pi^+$ and $\Xi^0_c\pi^+$ modes. The same for the BELLE experiment, without any evidence for a Ξ^+_{cc} in the $\Lambda^+_cK^-\pi^+$ mode. In the case of e^+e^- collisions, Belle has produced double charm quarks in the final state, $J/\psi + c\bar{c}$, however the cross section is very small $\sigma(e^+e^- \to J/\psi + c\bar{c}) = (0.74 \pm 0.08)$ pb and $J/\psi X_{\mathrm{non}c\bar{c}}$ cross section is $(0.43 \pm 0.09 \pm 0.09)$ pb [5], not being able to produce the $c\bar{c}$ pair without J/ψ in the final state. More likely, they could be observed by the LHC in pp collisions or in JPARC, and being fortunated, the experimentalist could find both, the missed double charm baryon and meson in the final state of the same reaction.

References

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