Hadron Loop Effects on Exotic Charm Mesons

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The X(3872) state was first observed in 2003 by Belle [1] and since then, it has received much attention. The important and interesting point is that the X(3872) seems to be difficult to explain its structure by a simple $c\bar{c}$ bound state using the quark potential model [2]. Many solutions of this problem have been suggested such as a tetraquark structure and a $D^0\bar{D}^{0*}$ molecule.

One of the authers (S. T.) has studied the X(3872) using a quark potential model by introducing an extra $(q\bar{q})$ pair to a $c\bar{c}$ system [3] and found a bound state of $q\bar{q}c\bar{c}$ with $J^{PC} = 1^{++}$. The purpose of the present work is to make the situation of the X(3872) clear by studying the effects of the $c\bar{c}$ core state coupling to the multi-hadronic states such as $D^0\bar{D}^{0*}$, $\rho J/\Psi$, $\omega J/\Psi$, $\pi^+\pi^- J/\Psi$, etc. This approach complements the quark model approach We use the Green's function approach of the nonrelativistic quantum mechanics with the Yamaguchi potential type of the nonlocal separable interactions between these states. We expect that the shape of the energy spectrum reflects the structure of the X(3872) and therefore by comparing between the shape of the spectrum obtained by the model calculation and that of the experiment, we shall be able to determine the structure of the X(3872). We consider that the present approach is applicable to the other exotic states.

In Fig. 1, we show the energy spectrum of the $D^0\bar{D}^{0*}$ system with a weak attractive interaction. In the case of the $D^0\bar{D}^{0*}$ coupling to the $c\bar{c}$ core state of $m = 3950$ MeV, the calculated spwctrum is shown in Fig. 2. In both cases, we choose the coupling strengths so as to make the bound states of $m \sim 3865$ MeV, which are not shown in Figs. In both figures the horizontal axes are in units of GeV and the vertical axes are in arbitrary units. We favor the spectrum in Fig. 2.

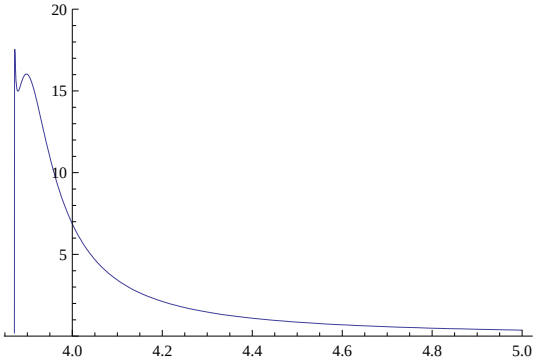

Figure 1:

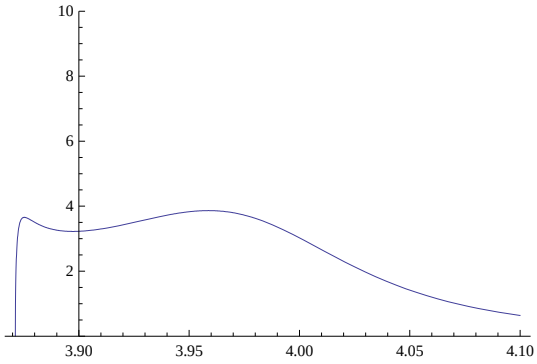

Figure 2:

[1] S.-K. Choi, et al., [Belle Collaboration], Phys. Rev. Lett. 91 (2003) 262001.

[2] For a review, see E.S. Swanson, Phys. Rep. 429 (2006) 243,

[3] S. Takeuchi, Prog. Theor. Phys. Suppl. 168 (2007) 107.