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## Coupled channel description for X(3872) and other XYZ mesons

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In the last years a number of exciting discoveries of new hadron states have challenged our description of the hadron spectroscopy. Among the several charmonium states (X(3940), Y(3940), Z(3930)) the most mysterious one is the well established X(3872). It was first discovered by the Belle Collaboration in the  $J/\psi\pi\pi$  invariant mass spectrum of the decay  $B \to K^+ \pi^+ \pi^- J/\psi$ . Its mass and relative decay rates outlines a puzzling structure. The  $\gamma J/\psi$  and  $\gamma \psi'$ decay rates suggest a  $c\bar{c}$  structure whereas the ratio  $X(3872) \rightarrow \pi^+\pi^-\pi^0 J/\psi$  to  $X(3872) \rightarrow \pi^+\pi^- J/\psi$ which is almost 1 indicates a large isospin violation incompatible with a traditional charmonium assumption. On the other hand the  $\overline{X}(3872)$  mass is difficult to reproduce by the standard quark models. The state appears to be too heavy for a 1D charmonium state and too light for a 2P charmonium one. In this work, we have performed a coupled channel calculation of the  $1^{++}$  sector including both  $c\bar{c}$  and  $DD^*$ states. The calculation was done in the framework of the constituent quark model of Ref. [1]. Two and four quark configurations are coupled using the  ${}^{3}P_{0}$  model. All the parameters are taken from the previous calculation in the  $c\bar{c}$ sector including the  $\gamma$  parameter of the  ${}^{3}P_{0}$  model [2], so the calculation is parameter free. We first perform an isospin symmetric calculation including  ${}^{3}S_{1}$  and  ${}^{3}D_{1} DD^{*}$  partial waves. If we neglect the coupling to  $c\bar{c}$  states we don't get a bound state for the  $DD^*$  molecule in the  $1^{++}$  channel, neither in the I = 0 nor in the I = 1 channels. When the coupling to  $c\bar{c}$  states is included we find an almost pure  $c\bar{c}(1^3P_1)$  state with mass 3467 MeVwhich we identify with the  $\chi_{c_1}(1P)$  and two states with significant molecular admixture. One of them with mass 3865 MeV is almost a  $DD^*$  molecule bound by the coupling to the  $c\bar{c}$  states. The second one, with mass 3936 MeV, is a  $c\bar{c}(2^{3}P_{1})$  with sizable  $DD^*$  component. We assign the first state to the X(3872), being the second one a candidate to the X(3940). When the mass difference between neutral and charged states is included a large  $D^0 D^{*0}$  component is found which dominates for large distances and breaks isospin symmetry in the physical state. If we extend the same model to other XYZ charmonium states we get a  $2^{++}$  at M=3968 MeV which can be identified with the Z(3930), but we do not find any candidate for the Y(3940). As a summary, we have shown that the X(3872) emerges in a constituent quark model calculation as a mixed state of a  $DD^*$  molecule and

quark model calculation as a mixed state of a  $DD^+$  molecule and  $\chi_{c_1}(2P)$  state. This framework may explain simultaneously the isospin violation showed by the experimental data and the radiative decay rates. We interpret the X(3940) as the  $\chi_{c_1}(2P)$  state with a significant  $DD^+$  component. Within the same model the Z(3930) appears as a  $2^{++}$  charmonium state.

J. Vijande, F. Fern\'andez, and A. Valcarce,
J. Phys G {\bf 31}, 481 (2005).
J. Segovia, A.M. Yasser, D. R. Entem, F. Fernandez
Phys. Rev. D {\bf 78}, 114033 (2008).

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