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Heavy-quark spin-symmetry partners of hadronic molecules

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Implications of heavy-quark spin-symmetry (HQSS) are investigated for the isoscalar charmonium-like state $X(3872)$ and the isovector bottomonium-like states $Z_b(10610)$ and $Z_b(10650)$ under the assumption of the latter being bound states of the nearby heavy meson-antimeson pairs (see Refs. [1,2] for more details). We formulate and solve a system of the integral equations for a coupled-channel problem involving the $P\bar{P}$, $P\bar{V}$, and $V\bar{V}$ channels (with P and V being either D and D^* or B and B^*) to determine the scattering amplitudes with the quantum numbers $J^{PC} = 1^{++}, 1^{+-}, 0^{++}$, and 2^{++}. The coupled-channel potentials incorporate the contact and one-pion exchange (OPE) interactions derived in a chiral effective field theory approach and iterated to all orders.
Once two contact terms at leading order are adjusted to reproduce the binding energies of the states used as input, the approach can be employed to predict the mass and the prominent contributions to the width of the spin-partner states with the quantum numbers J^{++} ($J = 0, 1, 2$). In particular, in the b-quark sector we predict the existence of a
narrow 2^{++} tensor state W_{b2}, with the width of the order of a several MeV, lying a few MeV below the $B^*\bar{B}^*$ threshold which is, therefore, expected to produce a visible resonant structure in the line shapes. The corresponding tensor state in the c-quark sector is also predicted but it is shown to have a much larger width.

It is pointed out that the OPE potential in combination with the HQSS breaking due to the nonvanishing V-P mass splitting has a significant impact on the location of the partner states. The leading effect from the OPE originates from the (S-D) tensor forces that implies that a perturbative inclusion of OPE is not sufficient. We emphasize that many particle coupled-channel transitions between various heavy meson-antimeson pairs are governed by the tensor part of OPE and thus a proper account for the coupled-channel dynamics is important to allow for reliable predictions of the spin-partner states.

[1] V. Baru, E. Epelbaum, A. A. Filin, C. Hanhart and A. V. Nefediev,
"Spin partners of the $Z_b(10610)$ and $Z_b(10650)$ revisited," arXiv:1704.07332 [hep-ph].

[2] V. Baru, E. Epelbaum, A. A. Filin, C. Hanhart, U.-G. Meißner and A. V. Nefediev, "Heavy-quark spin symmetry partners of the X (3872) revisited," Phys. Lett. B763, 20 (2016).

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