Contribution ID: **178** Type: **Poster**

Spectroscopy of the All-Charm Tetraquark

Tuesday 26 September 2017 20:45 (15 minutes)

We introduce a non-relativistic framework to study the spectroscopy of hadronic bound states composed of four charm quarks in the diquark-antidiquark picture. By numerically solving the Schr\"{o}dinger equation with two different Cornell-inspired potentials in a similar way of heavy quarkonium models of mesons, we factorize the 4-body problem into three 2-body systems: first the diquark and the antidiquark, which are composed of 2 quarks (antiquarks) into a color antitriplet state. In the next step they are considered as the tetraquark building blocks, where their interaction leads to a color singlet. Spin-dependent terms (spin-spin, spin-orbit and tensor) are used to describe the splitting structure of the spectrum and account for different quantum numbers of each state. Special attention is given to the tensor interaction between two particles of spin 1, with a detailed discussion of the adopted strategy. The spin-spin interaction is addressed perturbatively in the first model and included in the zeroth-order potential in the second one. The contribution of each interaction term is also analysed and compared. Recent experimental data of reasonably well-established charmonium mesons are used to fix the parameters of both models (with a fitting procedure minimizing χ^2), obtaining a satisfactory reproduction of charmonium spectrum. The differences between models are discussed in the charmonium, diquark and tetraquark context. We conclude that almost all the S and P waves (and respective first radial excitations), of the all-charm tetraquark composed by spin 1 diquarks are in the range between 5.8 to 7 GeV, above the threshold of spontaneous decay in low-lying charmonium pairs, like two η_c or J/ψ, what suggests that this could be the ideal channels to look for these states, and develop the current understanding of multiquark states.

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Session Classification: Poster session

Track Classification: Exotic states and candidates