Reference

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1 - 25 DN, $\pi\Sigma_c$ Interaction in Finite Volume and $\Lambda_c(2595)$ Resonance

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One of the topics where efforts are recently devoted within Lattice QCD is the determination of hadron spectra, both in the meson and baryon sector. After earlier claims of a successful determination of the hadron spectra using rough approximations and large pion masses, work continues along this line with more accurate approaches and problems are arising that were not envisaged at first glance. The "avoided level crossing" is usually taken as a signal of a resonance, but this criteria has been shown insufficient for resonances with a large width. The use of Luescher's approach[1] is gradually catching up. It is suited for the case when one has resonances with one decay channel in order to produce phase shifts for this decay channel from the discrete energy levels in the box. Yet, most of the hadronic resonances have two or more decay channels and the need to go beyond Luescher's approach becomes obvious.

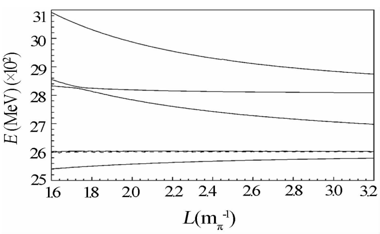

Fig. 1 Energy levels as functions of the cubic box size $L(m_\pi^{-1})$ derived from the chiral unitary approach.

In our work, we study the interaction of the coupled channels DN and $\pi\Sigma_c$ in an $SU(4)$ extrapolation of the chiral unitary theory. The resulting interaction is used to reproduce the position of the $\Lambda_c(2595)$ resonance in the isospin zero DN channel. Then we conclude that the $\Lambda_c(2595)$ is mostly a DN bound state. We then study the interaction of the coupled channels DN and $\pi\Sigma_c$ in the finite volume. Energy levels in the finite box are evaluated as shown in Fig. 1. We assume that the results obtained would correspond to results given by lattice calculations. From there we address the inverse problem. We propose a rather general and realistic potential and, using two coupled channels, a fit to the synthetic data is made assuming some reasonable errors in the data. Then this potential is used in the infinite volume case, generating the $\pi\Sigma_c$ phase shifts within an error band around the original results. This part provides information for lattice QCD calculations about the accuracy in the energies of the spectrum needed to get a desired accuracy in the phase shifts.

A second part of the investigation was about the use of a one channel Luescher's approach, with just the open $\pi\Sigma_c$ channel, to induce $\pi\Sigma_c$ phase shifts from the finite volume spectrum. We found in this case that, due to the large weight of the closed DN channel in this problem, the results obtained using Luescher's approach with just the $\pi\Sigma_c$ channel was of no use. Even more, making a fit analysis to the lattice data with just the $\pi\Sigma_c$ channel produced erroneous $\pi\Sigma_c$ phase shifts. Certainly one does not know a priori from the lattice QCD results whether two channels would be necessary in the analysis.

Reference

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