Low lying $J^P = 1/2^-$ resonances from chiral unitary dynamics

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Establishing the nature of baryon resonances is one of the primary goals in the field of hadronic physics. In the last few decades, intensive theoretical and experimental effort has been devoted to clarify whether the known resonances behave as genuine three quark states or can be dynamically generated through the iteration of apropriate non-polar terms of the meson-baryon interaction.
In the last decade, chiral perturbation theory (χPT) has emerged as a powerful scheme to describe low-energy meson-meson and meson-baryon dynamics, but it is limited to *low energies* and cannot describe the physics close to *resonances* (poles in the T-matrix). These two shortcomings have been recently circumvented by combining chiral dynamics with non-perturbative unitarization techniques (UχPT).
We will report on how the complete nonet of low-lying $J^P = 1/2^-$ resonances can be generated dynamically from the lowest-order meson-baryon chiral Lagrangian in s-wave. Unitarity is implemented through the N/D method in coupled channels which, in the absence of unphysical cuts, amounts to solving an algebraic Bethe-Salpeter equation in which the amplitudes are factorized on-shell out of the meson-baryon loop integral.
More explicitly, we will see in the $S = -1$ sector how the SU(3) singlet $\Lambda(1405)$, elusive in quark models, appears naturally as a dynamical pole of the $K^- p$ amplitude, adjusting only one parameter, the cut-off used to regularize the meson-baryon loop function [1]. An extension of the model to higher energies, through the use of dimensional regularization, generates the $\Lambda(1670)$ and the $\Sigma(1620)$, both belonging to the octet, with the $\Lambda(1670)$ qualifying as a quasibound $K\Xi$ state [2]. The $S = 0$ sector has been more difficult to describe with only a few parameters, but the approach is also able to reproduce the πN data moderately well around the energy of the $N(1535)$ [3]. Improvements are obtained by including the three-body $\pi\pi N$ channel and a moderate modification of the chiral coefficients inspired in vector meson dominance models [4]. We will put special emphasis in our last work in the $S = -2$ sector [5], where a pole is found around 1606 MeV corresponding to a Ξ resonance, hence completing the nonet of low-lying states with $J^P = 1/2^-$. We give supporting arguments to identify this resonance with the $\Xi(1620)$ state, quoted in the Particle Data Book as having $I = 1/2$ but with unknown spin and parity.

References

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