

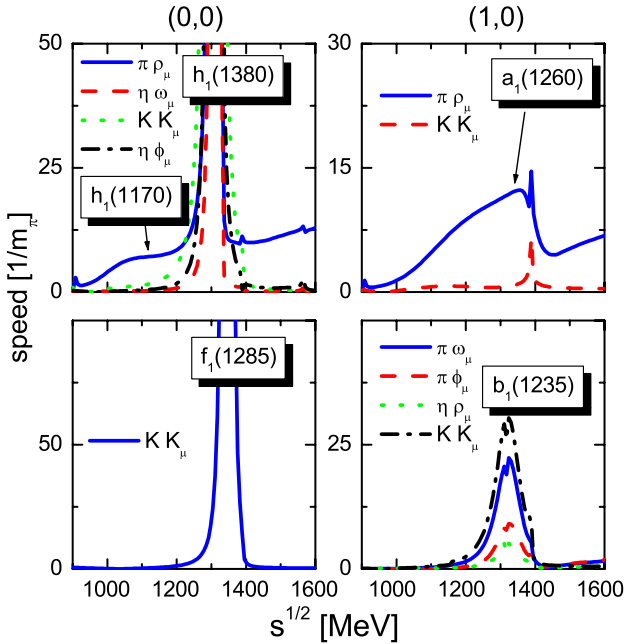
On meson resonances and chiral $SU(3)$ symmetry

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A profound understanding of the nature of meson and baryon resonances is one of the outstanding issues of QCD. The discovery of meson and baryon resonance states with exotic quantum numbers turns this into a burning question deserving prime attention. The goal is to establish a systematic approach which is capable of describing and predicting the resonance spectrum of QCD quantitatively. In this context the authors radical conjecture [1, 2, 3] that meson and baryon resonances that do not belong to the large- N_c ground state of QCD should be generated in terms of coupled-channel dynamics strongly questions the quantitative applicability of the constituent-quark model to the resonance spectrum. In more explicit terms we expect that the resonance spectrum of QCD in the (u, d, s) -sector should be described in terms of the baryon-octet $\frac{1}{2}^+$ and baryon-decuplet $\frac{3}{2}^+$ fields together with the Goldstone boson 0^- and vector meson 1^- fields. In the large- N_c and heavy-quark mass limit of QCD the latter baryon fields and also the latter meson fields have degenerate masses. If this change of paradigm is justified it requires to provide an explanation of the many meson and baryon resonances established experimentally.

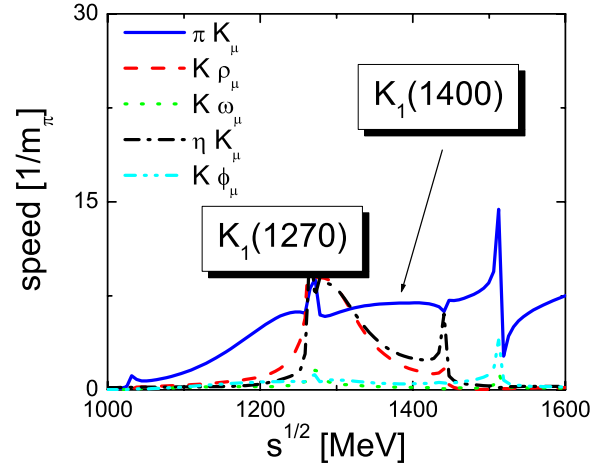
It is long known that the spectrum of light scalar mesons can be successfully reproduced in terms of coupled-channel dynamics as first pointed out by Törnqvist [4] and Van Beveren [5] in the 80s. In recent years this idea has been systematized by applying the chiral Lagrangian (see e.g. [6, 7]). Guided by the heavy-quark mass limit in which one expects a degeneracy of the 0^+ and 1^+ spectrum it is naturally to expect a similar description of the axial-vector meson spectrum [3].



The spectrum of axial-vector mesons as represented in the two figures in terms of generalized speed plots [3] is obtained by studying the scattering of Goldstone bosons off vector mesons using the leading order chiral Lagrangian.

Since the intermediate vector mesons have in part a substantial decay width we allow for spectral distributions of the broadest vector mesons, the ρ_μ - and K_μ -mesons. Our results are parameter-free once we insist on approximate crossing symmetric scattering amplitudes. We find that chiral symmetry predicts the existence of the axial-vector meson resonances ($h_1(1170)$, $h_1(1380)$, $f_1(1285)$, $a_1(1260)$, $b_1(1235)$, $K_1(1270)$, $K_1(1400)$) with a spectrum that is surprisingly close to the empirical one. A result analogous to the baryon sector [8, 9] is found: in the heavy $SU(3)$ limit with $m_{\pi, K, \eta} \simeq 500$ MeV and $m_{\rho, \omega, K^*, \phi} \simeq 900$ MeV the resonance states turn into bound states forming two degenerate octets and one singlet of the $SU(3)$ flavor group with masses 1360 MeV and 1280 MeV respectively. Taking the light $SU(3)$ limit with $m_{\pi, K, \eta} \simeq 140$ MeV and $m_{\rho, \omega, K^*, \phi} \simeq 700$ MeV we do not observe any bound-state nor resonance signals anymore. Since the leading order interaction kernel scales with N_c^{-1} the resonances disappear also in the large- N_c limit. Using physical masses a pattern arises that compares surprisingly well with the empirical properties of the $J^P = 1^-$ meson resonances.

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References

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