Scalar mesons, four quark models and $K-\bar{K}$ molecules

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The interpretation of the nature of scalar mesons has been controversial for over thirty years. There is still no general agreement whether they are $q\bar{q}$ states, glueballs, multiquark systems, $K-\bar{K}$ molecules or other meson-meson bound states [1]. All these questions are crucial for fully understanding the hadron structure and the confinement mechanism. In this contribution we focus on the structure of the nearly degenerated mesons $f_o(980)$ and $a_o(980)$ in the framework of a constituent quark model which has been able to describe the N-N phase shifts, the deuteron phenomenology [2], the triton binding energy [3] and the baryon spectra [4]. This model is based on the idea that between the scale of spontaneous breakdown of chiral symmetry and the scale of confinement, QCD may be formulated as an effective theory of constituent quarks interacting through gluons and Goldstone modes associated to chiral symmetry breaking.
Using this interaction we solve the Schrödinger equation for the $q\bar{q}$ system and we perform a variational calculation [5] for the four-quark system. The spectra of pseudoscalar and vector mesons are well reproduced assuming a $q\bar{q}$ structure. However the scalar $a_o(980)$ and $f_o(980)$ appear as non degenerated.
For the four quark system we consider two configurations, $[(qq)\,(\overline{ss})]$ and $[(qs)\,(\overline{qs})]$, the second one describing the structure of the a_0 and the f_0 mesons. The isospin dependent piece of the qq interaction, which comes from the Goldstone boson exchange, is much more important in the $[(qq)\,(\overline{ss})]$ coupling than in the $[(qs)\,(\overline{qs})]$ one. Therefore within the first configuration the binding energies of the states with $I=0$ and $I=1$ are very different while they appear nearly degenerated when the second one is assumed. Then our results supports the hypothesis that the a_0 and f_0 states may have a multiquark structure.
A description of the a_0 and f_0 in terms of a $K-\bar{K}$ structure in a RGM-like formalism with the same $q-q$ interaction is now in progress.

References

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