Revisit to Low Mass Scalar Mesons via Unitarized Chiral Perturbation Theory

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In this paper we revisit to issues around the low mass scalar mesons with use of the multichannel Inverse Amplitude Method(IAM) of the Chiral Perturbation Theory. Although the overall fits have already been given using the full T_4 amplitudes by Goméz Nicola and Pelàez(1), we want to understand the contents of the fits, that is, how resonanses are produced or not. For this purpose we adopt the Oller-Oset-Pelàez (OOP) version of the IAM(2), since the OOP version is much simple and describes rather well the qualitative behavior of the data. The OOP version picks up only the polynomial terms, T_4^P's with the coefficients L_n's and the s-channel loop terms out of the full $O(p^4)$ amplitudes, neglecting the left hand singularities. It may be said that the OOP version is like the K-matrix approximation to the full amplitude. The Lagrangian of the ChPT does not incorporate any resonance fields as preexisting particles, and then it offers a good theoretical framework to study the issues. Of course, this does not mean that the existence or nonexistence of a resonance can be completely predicted by the IAM, since the theory contains a set of the phenomenological parameters L_n with $n = 1$ to 8, which should be determined by the experimental data. Our set of L_n's turns out to be close to the sets of ChPT (1995) and Ref.(1).

Our conclusions on the scalar mesons viewed from the OOP version of the 2×2 channel IAM are summarized as follows:

1. The expected nonet structure of the scalar mesons below 1 GeV does not hold.

2. The $f_0(980)$ state is a typical example of the bound state resonance(3): The $K\bar{K}$ scattering amplitude has a bound state pole on the real axis, if the channel coupling is switched off, and the channel coupling moves the pole into the second sheet and generates the resonant behavior near the $K\bar{K}$ threshold. But its explicit resonant form is hidden in the large $\pi\pi$ background.

3. The $a_0(980)$ state appears as the strong cusp, not as the resonance in our parameter set L_n's. The origin of $a_0(980)$ is not the $K\bar{K}$ bound state pole but the channel coupling between the $\pi\eta$ and $K\bar{K}$ channels. This gives a sharp peak at the $K\bar{K}$ threshold, but the elastic $\eta\pi$ phase shift cannot exceed 90° below the $K\bar{K}$ threshold.

4. The broad peak of the isoscalar-scalar $\pi\pi$ mass distribution centered at 500 MeV need not be interpreted as the conventional resonance. This enhancement is generated essentailly by chiral symmetry and unitarity. The $\kappa(900)$ state is also not the conventional resonance similar to σ.

The mechanism to generate $f_0(980)$ and $a_0(980)$ is similar to the $K\bar{K}$ molecule model discussed by Weinstein and Isgur using the nonrelativistic quark model(4) and Jülich group using the meson exchange models(5), though our theoretical framework is much different from theirs. Our piont of view of the sigma meson is similar to Refs.(6).

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