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The pseudoscalar meson and baryon octet interaction with strangeness zero in the unitary coupled-channel approximation

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The pion-nucleon interaction is an interesting topic and has attracted more attentions of the nuclear society in the past decades.
There are two very closed excited states of the nucleon in the S_{11} channel, $N(1535)$ and $N(1650)$, which are difficult to be described within the framework of the constituent quark model. However, in the unitary coupled-channel approximation of the Bethe-Salpeter equation, most of the excited states of the nucleon are treated as resonance states of the pseudoscalar meson and the baryon in the $SU(3)$ flavor space, so are these two particles.

The $s-$ channel, $u-$ channel and Weinberg-Tomozawa contact potentials of the pseudoscalar meson and baryon octet in the S-wave approximation are calculated, and it is found that the πN $s-$ channel potential is repulsive and the other $s-$ channel potential are weaker than the πN case, while the $u-$ channel potentials in the S-wave approximation are attractive.
Although the curves for ηN and $K\Sigma$ cases are not smooth when $\sqrt{s} < 1300$MeV, it is far away from the energy region which we are interested in, and we assume that it would not give an effect on the pole position of the amplitude in the calculation.
However, the contact interaction originated from the Weinberg-Tomozawa term is dominant in the pseudoscalar meson and the baryon octet potential, and the correction from the $s-$ channel potential and the S-wave $u-$ channel potential is not important.

A pole is generated dynamically at $1518 - i46$MeV on the complex energy plane of $\sqrt{s}$ by solving the Bethe-Salpeter equation in the unitary coupled-channel approximation with the 19th set of parameters, i.e., $a_{\pi N} = -2.0$, $a_{\eta N} = -1.7$, $a_{K\Lambda} = -3.2$ and $a_{K\Sigma} = -3.2$.

In this work, the interaction of the pseudoscalar meson and the baryon octet is studied within a nonlinear realized Lagrangian. The $s-$, $u-$ channel potentials and the Weinberg-Tomozawa contact interaction are obtained when the three-momenta of the particles in the initial and final states are neglected in the S-wave approximation.

In the sector of isospin $I = 1/2$ and strangeness $S = 0$, a resonance state is generated dynamically by solving the Bethe-Salpeter equation, which might be regarded as counterparts of the $N(1535)$

particle listed in the PDG data.
We find the hidden strange channels, such as ηN, $K\Lambda$ and $K\Sigma$, play an important role in the generation of the resonance state when the Bethe-Salpeter equation is solved in the unitary coupled-channel approximation.
The coupling constants of this resonance state to different channels are calculated, and it is found that it couples strongly to the hidden strange channels.

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