Vol. 29 (1998) *ACTA PHYSICA POLONICA B* No 11

ISOSCALAR S-WAVE π–π INTERACTION IN THE NUCLEAR MEDIUM* **

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(Received June 17, 1998)

The s-wave isoscalar $\pi\pi$ scattering amplitude in a nuclear medium has been evaluated using a non-perturbative unitary coupled channels method and the standard chiral Lagrangians. The method is successful describing the $\pi\pi$ properties in vacuum, in the scalar-isoscalar channel up to 1.2 GeV giving rise to poles in the T matrix for the $f_0(980)$ and the σ. The extension of the method to the nuclear medium implies the renormalization of the pions in the medium and also the introduction of interaction terms related to contact terms in the $\pi N \to \pi\pi N$ reaction.

PACS numbers: 13.75.Lb, 14.40.Aq

1. Introduction

The π–π interaction in the σ channel can be strongly modified in the nuclear medium. The attractive p-wave interaction of the pion with the nucleus could lead to a shift of strength of the $\pi\pi$ system to low energies [1]. The possibility that some effects of this shift could have already been observed in the $(\pi, 2\pi)$ reaction in nuclei [2] was discussed in Ref. [1]. New experimental data [3] show an enhancement in the $\pi^+\pi^-$ channel that is absent in the

* Presented at the Meson'98 and Conference on the Structure of Meson, Baryon and Nuclei, Cracow, Poland, May 26–June 2, 1998.
** Partly supported by DGICYT contract number PB96-0753

$\pi^+\pi^+$ channel, what might give further support to that conjecture. A good presentation of the current theoretical understanding of the σ channel in the nuclear medium can be found in Refs [4, 5].

We present here a study based on the model for the scalar-isoscalar π–π interaction in vacuum developed in Ref. [6]. It is basically, a nonperturbative approach which combines coupled channel Lippmann–Schwinger equation with meson–meson potentials provided by the lowest order chiral Lagrangians. The model is very successful an requires only one free parameter (a momentum cutoff taken to be 1 GeV). The phase shifts and inelasticities are well reproduced up to about 1.2 GeV. The σ and $f_0(980)$ resonances appear as poles in the $J = T = 0$ channel. The coupling of channels was found essential to produce the $f_0(980)$ resonance, while the σ pole was not much affected by the coupling of the pions to $K\bar{K}$.

2. π–π interaction in the nuclear medium

The Lippmann–Schwinger equation of Ref. [6] is modified by allowing the pions to excite nucleons and Δ's in the nuclear medium. Graphically, this procedure can be represented by the diagrams of Fig. 1

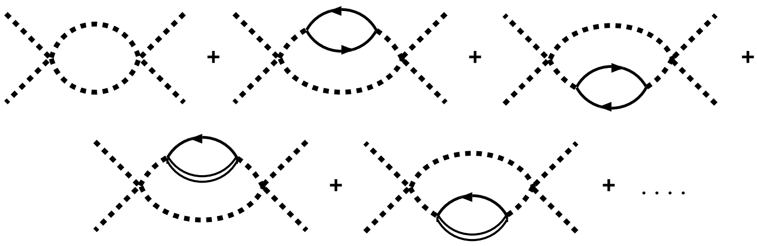

Fig. 1. Terms appearing in the $\pi\pi$ scattering matrix

where the dashed lines are pions, and the solid line bubbles are ph and Δh excitations. At the same order in density we also must include the diagrams of Fig. 2. There are important cancellations between the diagrams of Fig. 1 and those of Fig. 2 which contribute to simplify the calculations.

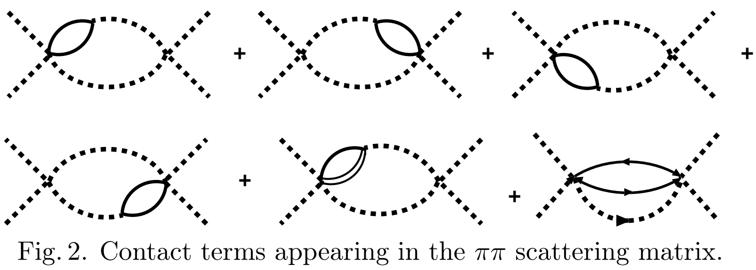

Fig. 2. Contact terms appearing in the $\pi\pi$ scattering matrix.

Finally, we solve the coupled channels LS equation, including also the $K\bar{K}$ channel, and higher orders in the renormalization of the pion propagators. Details of the calculation can be found in Ref. [7]. We present our results for the imaginary part of the scattering amplitude in Fig. 3.

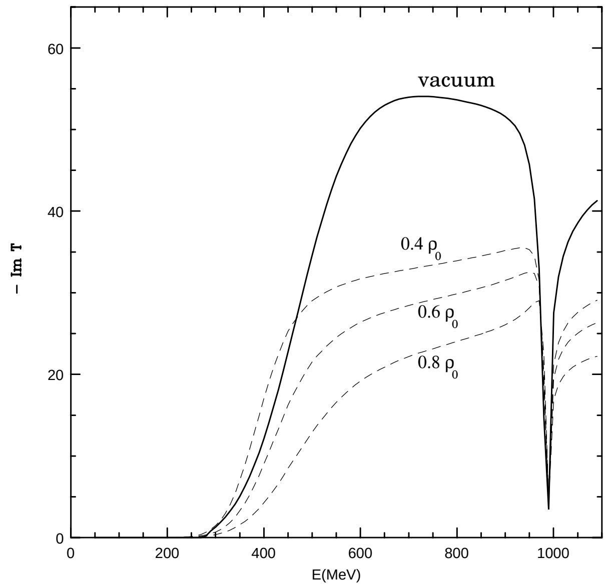

Fig. 3. Contact terms appearing in the $\pi\pi$ scattering matrix.

In agreement with previous calculations, that also implemented some chiral constraints, we do not find any relevant strength accumulation at low energies that could be detected experimentally. In fact, the imaginary part of the scalar isoscalar $\pi\pi$ scattering amplitude decreases monotonically as the density increases.

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