Nucleon-nucleon interaction in the scalar-isoscalar channel within the chiral unitary model

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We study the nucleon-nucleon interaction in the scalar-isoscalar channel using the chiral unitary model. The chiral unitary model is based on the non-linear chiral lagrangian, where the inverse t-matrix is expanded in terms of the pion momentum. The nucleon-nucleon interaction is expressed in terms of correlated two pion exchange interactions.

The chiral unitary model has been applied to meson-meson systems. The scalar and the vector channels were described very nicely as discussed in ref. [1]. In particular, the scalar channel could be described even with the lowest order term with a suitable cut-off of about $\Lambda \sim 1$GeV up to $\sqrt{s} \sim 1.2$GeV. In this case, the T-matrix is given by the lowest term, T_2, as

$$T = T_2[T_2 - T_2GT_2]^{-1}T_2 = [1 - T_2G]^{-1}T_2. \qquad (1)$$

The scattering cross sections have been reproduced very well as demonstrated in ref. [2] with the use of all the flavor SU(3) channels. This is in contrast with the chiral perturbation, which could be used only for small energies.

This success of the chiral unitary model is extremely encouraging for the description of hadron-hadron interactions from the microscopic theory as QCD. There are definitely hadrons of the quark origin. However, hadrons interact very strongly among them, which should be described with the care of the chirality. We can now rely on the chiral unitary model for the hadron-hadron interaction.

The chiral unitary model has been applied to the meson-meson systems and the meson-baryon systems. Hence, we would like to work out the baryon-baryon interaction now with the chiral unitary model. We calculate the diagrams shown in Fig.1, where the solid line denotes the baryon and the dashed line the pion. We iterate the interaction up to all orders using the chiral unitary model. As for the intermediate baryon state, we take the nucleon and the delta isobar. The details of the formulation for the T-matrix are described in ref. [3].

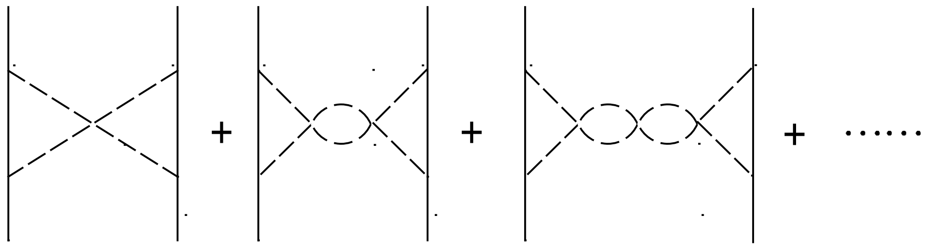

Figure 1: The Feynman diagram for the nucleon-nucleon interaction with correlated two pion exchanges described in the chiral unitary model.

We show in Fig.2 the nucleon-nucleon interaction in the scalar-isoscalar channel. As expected,there appears the intermediate attraction. We can extract the range and the strength from the intermediate attraction at $r \sim 2.5$fm. The range is expressed in terms of the mass as $m \sim 450$MeV, while the strength is $g \sim 8$. These values are close to those of the Bonn potential. [4]. It is amazing to get the short range repulsion in this channel as seen in Fig.2. This is completely new. In this sense, the use of the short range repulsion in the scalar-isoscaler channel as due to the Pomeron exchange in the Nijmegen potential is very interesting. [5] We need further study both from the chiral unitary model and also from the comparison with experimental data.

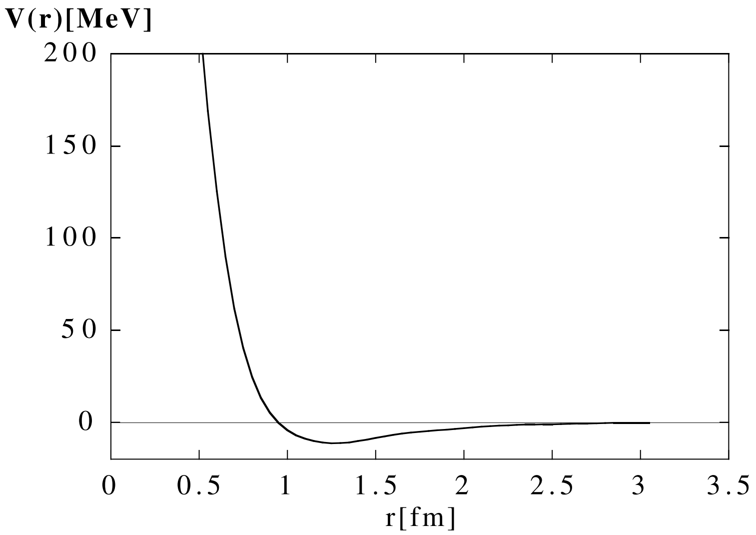

Figure 2: Nucleon-nucleon interaction in the scalar-isoscalar channel in MeV as a function of the distance r in fm.

It is now very interesting to study the baryon-baryon interaction in the flavor SU(3) channel. We shall follow the work of the Juelich group, but replace the meson-meson interaction by those of the chiral unitary model. [6]

References

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