Chiral $SU(3)$ Quark Model Study of Low Energy Nπ Scattering Phase Shifts*

HUANG Fei[1,2;1)] ZHANG Zong-Ye[1] YU You-Wen[1]

1 (Institute of High Energy Physics, CAS, Beijing 100049, China)
2 (Graduate School of the Chinese Academy of Sciences, Beijing 100049, China)

Abstract A dynamical study of the low energy nucleon-pion scattering phase shifts for S and P waves with isospin $I = 1/2$ and $I = 3/2$ is performed in the chiral $SU(3)$ quark model by solving a resonating group method equation. The model parameters are taken to be the values fitted by the energies of the baryon ground states and the kaon-nucleon elastic scattering phase shifts of different partial waves. Except for the resonant channels, the numerical results are in qualitative agreement with the experimental data.

Key words Nπ phase shifts, quark model, chiral symmetry

1 Introduction

As is well known, the Quantum Chromodynamics (QCD) is the underlying theory of the strong interaction. However, because of the complexity of the non-perturbative effect of QCD at the low energy region, the QCD-inspired models are still needed to be a bridge for understanding the observables. Since the last 20 years, the constituent quark model (CQM) has been quite successful in studying the baryon spectrum and nucleon-nucleon (NN) interaction[1—3]. Nevertheless, the CQM needs a logical explanation, from the underlying theory of the strong interaction, i.e. QCD, of the source of the constituent quark mass. Thus spontaneous vacuum breaking has to be considered, and as a consequence the coupling between the quark field and the Goldstone boson is introduced to restore the chiral symmetry. In this sense, the chiral quark model can be regarded as a development of the CQM and it is reasonable and useful to describe the medium-range nonperturbative QCD effect. By generalizing the $SU(2)$ linear σ model, a chiral $SU(3)$ quark model is developed to describe the systems with strangeness[4, 5]. This model can reasonably reproduce the energies of the baryon ground states, the binding energy of the deuteron, the NN scattering phase shifts of different partial waves, and the hyperon-nucleon (YN) cross sections by performing the resonating group method (RGM) calculations[4—6]. Inspired by these achievements, we try to extend this model to include an antiquark to study the baryon-meson interaction. In Refs. [7—9], we studied the S, P, D, F wave kaon-nucleon (KN) phase shifts and fortunately, we got a quite reasonable agreement with the experimental data. At the same time, the results also show that the effects of the s-channel quark-antiquark ($q\bar{q}$) annihilation interactions can be neglected in the scattering processes, since they act only in the very short range.

In this work, we try to study the Nπ scattering processes in the low energy regime by employing our chiral $SU(3)$ quark model. The model parameters are taken to be the values fitted by the energies of the baryon ground states and the experimental data of the KN elastic scattering. The $q\bar{q}$ annihilation and creation interactions are not included as a first step.

Received 24 February 2005, Revised 27 April 2005
*Supported by National Natural Science Foundation of China (10475087)
1) E-mail: hfbin@mail.ihep.ac.cn

A dynamical study of the S and P wave Nπ scattering phase shifts is performed by solving a RGM equation. The results with the isospin of Nπ $I=1/2$ and $I=3/2$ are both in qualitative agreement with the experimental data except for the resonant channels where the $q\bar{q}$ creation and annihilation interactions are expected to give significant contributions.

The paper is organized as follows. In the next section the framework of the chiral $SU(3)$ quark model is briefly introduced. The calculated results for the isospin $I=1/2$ and $I=3/2$ Nπ phase shifts of S and P partial waves are shown in Sec. 3, where some discussions are presented as well. Finally, the summary is given in Sec. 4.

2 Formulation

As is well known, the nonperturbative QCD effects are very important in light quark systems. To consider the low-momentum medium-range nonperturbative QCD effect, an $SU(2)$ linear σ model[10, 11] is proposed to study the NN interaction. In order to extend the study to the systems with strangeness, we generalized the idea of the $SU(2)$ σ model to the flavor $SU(3)$ case, in which a unified coupling between quarks and all scalar and pseudoscalar chiral fields is introduced and the constituent quark mass can be understood in principle as the consequence of a spontaneous chiral symmetry breaking of the QCD vacuum[4, 5]. With this generalization, the interacting Hamiltonian between quarks and chiral fields can be written as

$$H_I^{\mathrm{ch}}=g_{\mathrm{ch}}F(\boldsymbol{q}^2)\bar{\psi}\left(\sum_{a=0}^{8}\sigma_a\lambda_a+\mathrm{i}\sum_{a=0}^{8}\pi_a\lambda_a\gamma_5\right)\psi, \quad (1)$$

where g_{ch} is the coupling constant between the quark and the chiral-field, and λ_0 a unitary matrix. $\lambda_1,\ \cdots,\ \lambda_8$ are the Gell-Mann matrix of the flavor $SU(3)$ group, $\sigma_0,\ \cdots,\ \sigma_8$ the scalar nonet fields, and $\pi_0,\ \cdots,\ \pi_8$ the pseudoscalar nonet fields. $F(\boldsymbol{q}^2)$ is a form factor inserted to describe the chiral-field structure[12—15] and, as usual, it is taken to be

$$F(\boldsymbol{q}^2)=\left(\frac{\Lambda^2}{\Lambda^2+\boldsymbol{q}^2}\right)^{1/2}, \quad (2)$$

with Λ being the cutoff mass of the chiral field. Clearly, H_I^{ch} is invariant under the infinitesimal chiral $SU(3)_{\mathrm{L}}\times SU(3)_{\mathrm{R}}$ transformation.

From H_I^{ch}, the chiral-field-induced effective quark-quark potentials can be derived, and their expressions are given in the following:

$$V_{\sigma_a}(\boldsymbol{r}_{ij}) = -C(g_{\mathrm{ch}},\ m_{\sigma_a},\ \Lambda)X_1(m_{\sigma_a},\ \Lambda,\ r_{ij})\times [\lambda_a(i)\lambda_a(j)]+V_{\sigma_a}^{\boldsymbol{l}\cdot\boldsymbol{s}}(\boldsymbol{r}_{ij}), \quad (3)$$

$$V_{\pi_a}(\boldsymbol{r}_{ij})=C(g_{\mathrm{ch}},m_{\pi_a},\Lambda)\frac{m_{\pi_a}^2}{12m_{q_i}m_{q_j}}X_2(m_{\pi_a},\Lambda,r_{ij})\times (\boldsymbol{\sigma}_i\cdot\boldsymbol{\sigma}_j)[\lambda_a(i)\lambda_a(j)]+V_{\pi_a}^{\mathrm{ten}}(\boldsymbol{r}_{ij}), \quad (4)$$

and

$$V_{\sigma_a}^{\boldsymbol{l}\cdot\boldsymbol{s}}(\boldsymbol{r}_{ij}) = -C(g_{\mathrm{ch}},\ m_{\sigma_a},\ \Lambda)\frac{m_{\sigma_a}^2}{4m_{q_i}m_{q_j}}\times \left\{G(m_{\sigma_a}r_{ij})-\left(\frac{\Lambda}{m_{\sigma_a}}\right)^3G(\Lambda r_{ij})\right\}\times [\boldsymbol{L}\cdot(\boldsymbol{\sigma}_i+\boldsymbol{\sigma}_j)][\lambda_a(i)\lambda_a(j)], \quad (5)$$

$$V_{\pi_a}^{\mathrm{ten}}(\boldsymbol{r}_{ij})=C(g_{\mathrm{ch}},\ m_{\pi_a},\ \Lambda)\frac{m_{\pi_a}^2}{12m_{q_i}m_{q_j}}\times \left\{H(m_{\pi_a}r_{ij})-\left(\frac{\Lambda}{m_{\pi_a}}\right)^3H(\Lambda r_{ij})\right\}\times [3(\boldsymbol{\sigma}_i\cdot\hat{r}_{ij})(\boldsymbol{\sigma}_j\cdot\hat{r}_{ij})-\boldsymbol{\sigma}_i\cdot\boldsymbol{\sigma}_j]\,[\lambda_a(i)\lambda_a(j)], \quad (6)$$

with

$$C(g_{\mathrm{ch}},\ m,\ \Lambda)=\frac{g_{\mathrm{ch}}^2}{4\pi}\frac{\Lambda^2}{\Lambda^2-m^2}m, \quad (7)$$

$$X_1(m,\ \Lambda,\ r)=Y(mr)-\frac{\Lambda}{m}Y(\Lambda r), \quad (8)$$

$$X_2(m,\ \Lambda,\ r)=Y(mr)-\left(\frac{\Lambda}{m}\right)^3Y(\Lambda r), \quad (9)$$

$$Y(x)=\frac{1}{x}\mathrm{e}^{-x}, \quad (10)$$

$$G(x)=\frac{1}{x}\left(1+\frac{1}{x}\right)Y(x), \quad (11)$$

$$H(x)=\left(1+\frac{3}{x}+\frac{3}{x^2}\right)Y(x), \quad (12)$$

and m_{σ_a} is the mass of the scalar meson and m_{π_a} the mass of the pseudoscalar meson.

In the chiral $SU(3)$ quark model, besides the interaction of the coupling between quarks and chiral fields, which describes the nonperturbative QCD effect of the low-momentum medium-distance range, to study the baryon structure and hadron-hadron dynamics, one still needs to include an effective one-gluon-exchange interaction $V_{ij}^{\rm OGE}$ to govern the short-range behavior,

$$V_{ij}^{\rm OGE} = \frac{1}{4}g_i g_j \left(\lambda_i^{\rm c}\cdot\lambda_j^{\rm c}\right)\left\{\frac{1}{r_{ij}} - \frac{\pi}{2}\delta(\boldsymbol{r}_{ij})\left(\frac{1}{m_{q_i}^2} + \frac{1}{m_{q_j}^2} + \frac{4}{3}\frac{1}{m_{q_i}m_{q_j}}(\boldsymbol{\sigma}_i\cdot\boldsymbol{\sigma}_j)\right)\right\} + V_{\rm OGE}^{\boldsymbol{l}\cdot\boldsymbol{s}}, \quad (13)$$

with

$$V_{\rm OGE}^{\boldsymbol{l}\cdot\boldsymbol{s}} = -\frac{1}{16}g_i g_j \left(\lambda_i^{\rm c}\cdot\lambda_j^{\rm c}\right)\frac{3}{m_{q_i}m_{q_j}}\frac{1}{r_{ij}^3}\boldsymbol{L}\cdot(\boldsymbol{\sigma}_i + \boldsymbol{\sigma}_j), \quad (14)$$

and a confinement potential $V_{ij}^{\rm conf}$ to provide the non-perturbative QCD effect in the long distance,

$$V_{ij}^{\rm conf} = -a_{ij}^{\rm c}(\lambda_i^{\rm c}\cdot\lambda_j^{\rm c})r_{ij}^2 - a_{ij}^{\rm c0}(\lambda_i^{\rm c}\cdot\lambda_j^{\rm c}). \quad (15)$$

For the systems with an antiquark $\bar{\rm q}$, the total Hamiltonian can be written as[8, 9, 16]

$$H = \sum_{i=1}^{5}T_i - T_G + \sum_{i<j=1}^{4}V_{ij} + \sum_{i=1}^{4}V_{i\bar{5}}, \quad (16)$$

where T_G is the kinetic energy operator for the center-of-mass motion, and V_{ij} and $V_{i\bar{5}}$ represent the quark-quark (qq) and quark-antiquark ($\rm q\bar{q}$) interactions, respectively,

$$V_{ij} = V_{ij}^{\rm OGE} + V_{ij}^{\rm conf} + V_{ij}^{\rm ch}, \quad (17)$$

$$V_{ij}^{\rm ch} = \sum_{a=0}^{8}V_{\sigma_a}(\boldsymbol{r}_{ij}) + \sum_{a=0}^{8}V_{\pi_a}(\boldsymbol{r}_{ij}). \quad (18)$$

$V_{i\bar{5}}$ in Eq. (16) includes two parts: direct interaction and s-channel contributions,

$$V_{i\bar{5}} = V_{i\bar{5}}^{\rm dir} + V_{i\bar{5}}^{\rm schan}, \quad (19)$$

with

$$V_{i\bar{5}}^{\rm dir} = V_{i\bar{5}}^{\rm conf} + V_{i\bar{5}}^{\rm OGE} + V_{i\bar{5}}^{\rm ch}, \quad (20)$$

where

$$V_{i\bar{5}}^{\rm conf} = -a_{i\bar{5}}^{\rm c}\left(-\lambda_i^{\rm c}\cdot\lambda_5^{{\rm c}*}\right)r_{i\bar{5}}^2 - a_{i\bar{5}}^{\rm c0}\left(-\lambda_i^{\rm c}\cdot\lambda_5^{{\rm c}*}\right), \quad (21)$$

$$V_{i\bar{5}}^{\rm OGE} = \frac{1}{4}g_i g_5\left(-\lambda_i^{\rm c}\cdot\lambda_5^{{\rm c}*}\right)\left\{\frac{1}{r_{i\bar{5}}} - \frac{\pi}{2}\delta(\boldsymbol{r}_{i\bar{5}})\left(\frac{1}{m_{q_i}^2} + \frac{1}{m_{q_5}^2} + \frac{4}{3}\frac{1}{m_{q_i}m_{q_5}}(\boldsymbol{\sigma}_i\cdot\boldsymbol{\sigma}_5)\right)\right\} - \frac{1}{16}g_i g_5\left(-\lambda_i^{\rm c}\cdot\lambda_5^{{\rm c}*}\right)\frac{3}{m_{q_i}m_{q_5}}\frac{1}{r_{i\bar{5}}^3}\boldsymbol{L}\cdot(\boldsymbol{\sigma}_i + \boldsymbol{\sigma}_5), \quad (22)$$

and

$$V_{i\bar{5}}^{\rm ch} = \sum_j(-1)^{G_j}V_{i5}^{{\rm ch},j}. \quad (23)$$

Here $(-1)^{G_j}$ represents the G parity of the jth meson. $V_{i\bar{5}}^{\rm schan}$ is the s-channel $\rm q\bar{q}$ interactions, which are not included in the $\rm N-\pi$ interactions in this preliminary work.

All the model parameters are taken from our previous work[8, 9], which can give a satisfactory description of the energies of the baryon ground states and the S, P, D, F wave KN elastic scattering phase shifts. Here we briefly give the procedure of the parameters determination. We have three initial input parameters: the harmonic-oscillator width parameter $b_{\rm u}$, the up (down) quark mass $m_{\rm u(d)}$, and the strange quark mass $m_{\rm s}$. These three parameters are taken to be the usual values: $b_{\rm u} = 0.5$fm, $m_{\rm u(d)} = 313$MeV, and $m_{\rm s} = 470$MeV. By some special constraints, the other model parameters are fixed in the following way. The chiral coupling constant $g_{\rm ch}$ is fixed by

$$\frac{g_{\rm ch}^2}{4\pi} = \left(\frac{3}{5}\right)^2\frac{g_{\rm NN\pi}^2}{4\pi}\frac{m_{\rm u}^2}{M_{\rm N}^2}, \quad (24)$$

with $g_{\rm NN\pi}^2/4\pi = 13.67$ taken as the experimental value. The masses of the mesons are also taken to be the experimental values, except for the σ meson, where its mass is treated as an adjustable parameter and taken to be 675MeV by fitting the S wave KN phase shifts. The cutoff radius Λ^{-1} is taken to be the value close to the chiral symmetry breaking scale[12—15]. After the parameters of chiral fields are fixed, the one-gluon-exchange coupling constants $g_{\rm u}$ and $g_{\rm s}$ can be determined by the mass splits between N, Δ and Λ, Σ respectively. The confinement strengths $a_{\rm uu}^{\rm c}$, $a_{\rm us}^{\rm c}$, and $a_{\rm ss}^{\rm c}$ are fixed by the stability conditions of N, Λ, and Ξ, and the zero-point energies $a_{\rm uu}^{\rm c0}$, $a_{\rm us}^{\rm c0}$, and $a_{\rm ss}^{\rm c0}$ by fitting the masses of N, Σ and $\overline{\Xi+\Omega}$, respectively. All the parameters are tabulated in Table 1.

Table 1. Model parameters.

$m_{\rm u}$/MeV	313
$b_{\rm u}$/fm	0.5
$g_{\rm u}$	0.886
m_σ/MeV	675
$a_{\rm uu}^{\rm c}$/(MeV/fm^2)	52.4
$a_{\rm uu}^{\rm c0}$/MeV	−50.4

The meson masses and the cutoff mass: $m_{\sigma'} = 980$MeV, $m_\kappa = 980$MeV, $m_\varepsilon = 980$MeV, $m_\pi = 138$MeV, $m_{\rm K} = 495$MeV, $m_\eta = 549$MeV, $m_{\eta'} = 957$MeV, and $\Lambda = 1100$MeV.

Equipped with the chiral $SU(3)$ quark model with all the parameters determined, the low energy Nπ scattering phase shifts can be dynamically studied in the frame work of the RGM. The wave function of the five-quark system is taken as

$$\Psi=\mathcal{A}[\hat{\phi}_{\mathrm{N}}(\boldsymbol{\xi}_1,\boldsymbol{\xi}_2)\hat{\phi}_{\pi}(\boldsymbol{\xi}_3)\chi(\boldsymbol{R}_{\mathrm{N}\pi})], \tag{25}$$

where $\boldsymbol{\xi}_1$ and $\boldsymbol{\xi}_2$ are the internal coordinates for the cluster N, and $\boldsymbol{\xi}_3$ the internal coordinate for the cluster π. $\boldsymbol{R}_{\mathrm{N}\pi}\equiv\boldsymbol{R}_{\mathrm{N}}-\boldsymbol{R}_{\pi}$ is the relative coordinate between the clusters, N and π. The $\hat{\phi}_{\mathrm{N}}$ is the antisymmetrized internal cluster wave function of N, and $\chi(\boldsymbol{R}_{\mathrm{N}\pi})$ the relative wave function of the two clusters. The symbol $\mathcal{A}$ is the antisymmetrizing operator defined as

$$\mathcal{A}\equiv 1-\sum_{i\in \mathrm{N}}P_{i4}\equiv 1-3P_{34}. \tag{26}$$

Substituting Ψ into the projection equation

$$\langle\delta\Psi|(H-E)|\Psi\rangle=0, \tag{27}$$

we obtain the integro-differential equation for the relative function χ,

$$\int[\mathcal{H}(\boldsymbol{R},\boldsymbol{R}')-E\mathcal{N}(\boldsymbol{R},\boldsymbol{R}')]\,\chi(\boldsymbol{R}')\mathrm{d}\boldsymbol{R}'=0, \tag{28}$$

where the Hamiltonian kernel $\mathcal{H}$ and normalization kernel $\mathcal{N}$ can, respectively, be calculated by

$$\left\{\begin{matrix}\mathcal{H}(\boldsymbol{R},\boldsymbol{R}')\\ \mathcal{N}(\boldsymbol{R},\boldsymbol{R}')\end{matrix}\right\}=\Big\langle[\hat{\phi}_N(\boldsymbol{\xi}_1,\boldsymbol{\xi}_2)\hat{\phi}_\pi(\boldsymbol{\xi}_3)]\delta(\boldsymbol{R}-\boldsymbol{R}_{\mathrm{N}\pi}) \left|\left\{\begin{matrix}H\\ 1\end{matrix}\right\}\right| \mathcal{A}\left[[\hat{\phi}_N(\boldsymbol{\xi}_1,\boldsymbol{\xi}_2)\hat{\phi}_\pi(\boldsymbol{\xi}_3)]\delta(\boldsymbol{R}'-\boldsymbol{R}_{\mathrm{N}\pi})\right]\Big\rangle. \tag{29}$$

Eq. (28) is the so-called RGM equation. Expanding unknown $\chi(\boldsymbol{R}_{\mathrm{N}\pi})$ by employing the well-defined basis wave functions, such as Gaussian functions, one can solve the RGM equation for a scattering problem to obtain the scattering phase shifts for the two-cluster systems. The details of solving the RGM equation can be found in Refs. [8, 17—20].

3 Results and discussions

A dynamical calculation of S and P wave Nπ phase shifts in the low energy region with isospin $I=1/2$ and $I=3/2$ is performed in the framework of the chiral $SU(3)$ quark model by solving a RGM equation. In this preliminary work we do not consider the s-channel $\mathrm{q\bar{q}}$ interactions, which, as shown in Fig. 1, include four parts: annihilation to a gluon (Fig. 1(a)), annihilation to a scalar or pseudoscalar meson (Fig. 1(b)), annihilation to a gluon with the number of constituents changed (Fig. 1(c)), $\mathrm{q\bar{q}}$ creation from a gluon with the number of constituents changed (Fig. 1(d)). The processes changing the number of constituents regard the N^* and the Δ resonance.

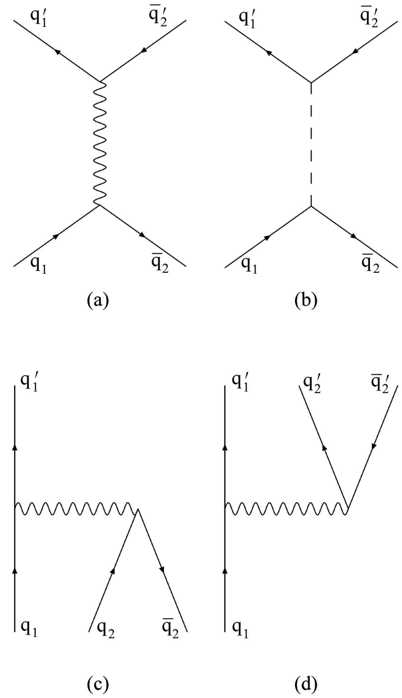

Fig. 1. Feynman diagrams of the $\mathrm{q\bar{q}}$ annihilation and creation interactions.

Our calculated results are shown in Figs. 2 and 3. Here we use the conventional partial wave notation $L_{2I\ 2J}$, where the first subscript denotes the twice of the isospin quantum number and the second one the

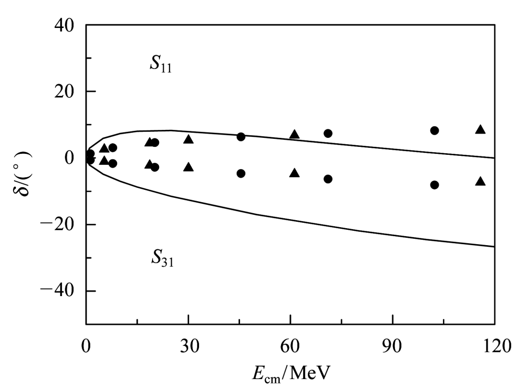

Fig. 2. The S-wave Nπ phase shifts.

twice of the total angular momentum of the Nπ system. The solid circles and the triangles correspond respectively to the phase shifts analysis of Arndt et al.[21] and Roper et al[22].

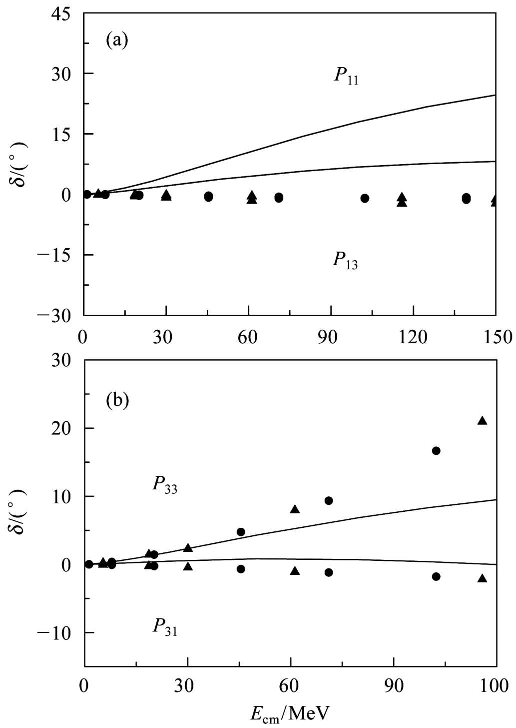

Fig. 3. The P-wave Nπ phase shifts.

First we look at those scattering phase shifts which cannot be influenced by the explicit q$\bar{q}$ creation and annihilation interactions changing the number of constituents (Fig. 1(c)—1(d)). These are the S_{11}, S_{31}, P_{13} and P_{31} channels. From Figs. 2 and 3 one can see that except for the S_{31} channel, for which the results are a little too repulsive, the calculated Nπ phase shifts are in qualitative agreement with the experimental data. This means that the t-channel qq and q$\bar{q}$ interactions obtained from our chiral quark model might be acceptable, and the s-channel q$\bar{q}$ interactions may be unimportant in these channels which is reasonable since in these channels there are really no Nπ resonance state in evidence. Now we focus on the P_{11} and P_{33} channels. We cannot reproduce the P_{11} channel phase shifts and the results for P_{33} channel are less attractive, especially in the higher energy domain. This can be easily understood because the s-channel q$\bar{q}$ interactions are dominantly important in these two channels, where P_{11} and P_{33} correspond to the Roper and the Δ(1232), respectively. To get a more satisfactory description of the Nπ interactions, the s-channel q$\bar{q}$ annihilation and creation interactions would be considered in our future work.

It should be mentioned that our results are independent of the confinement potential since between two color-singlet clusters the confinement potential scarcely contributes any effect[8, 9]. Thus our numerical results will almost remain unchanged even the color quadratic confinement is replaced by the color linear one.

Finally we'd like to emphasize that in this work, all the model parameters are determined by the energies of the octet and decuplet baryon ground states and the S, P, D, F wave KN phase shifts. In other words, there's no more free parameter in the Nπ phase shifts calculation. If one changes the mass of the σ meson to be smaller, certainly the calculated Nπ phase shifts would be more attractive, but, consequently, one cannot get the reasonable KN phase shifts, especially for the S-wave.

4 Summary

In summary, we perform a dynamical study of S- and P- wave low energy Nπ scattering phase shifts in the framework of the RGM by employing our chiral $SU(3)$ quark model. The model parameters are taken to be the values fitted by the energies of the baryon ground states and the S, P, D, F wave KN phase shifts. As a preliminary study the s-channel q$\bar{q}$ interactions are not included. The results of the non-resonant channels are in qualitative agreement with the experimental data. This means the t-channel qq and q$\bar{q}$ interactions obtained from our chiral quark model might be reasonable. To get a more satisfactory description of the Nπ interactions the s-channel q$\bar{q}$ interactions will be considered in our future work.

References

1 Isgur N, Karl G. Phys. Rev., 1978, **D18**: 4187

2 Isgur N, Karl G. Phys. Rev., 1979, **D19**: 2653

3 Glozman L Ya, Riska D O. Phys. Rep., 1996, **268**: 263

4 ZHANG Z Y, Faessler A, Straub U et al. Nucl. Phys., 1994, **A578**: 573

5 ZHANG Z Y, YU Y W, SHEN P N et al. Nucl. Phys., 1997, **A625**: 59

6 DAI L R, ZHANG Z Y, YU Y W et al. Nucl. Phys., 2003, **A727**: 321

7 HUANG F, ZHANG Z Y, YU Y W. Commun. Theor. Phys., 2004, **42**: 577

8 HUANG F, ZHANG Z Y, YU Y W. Phys. Rev., 2004, **C70**: 044004

9 HUANG F, ZHANG Z Y. Phys. Rev., 2004, **C70**: 064004

10 Gell-Mann M, Levy M. Nuovo Cimento, 1960, **XVI**: 705

11 Fernandez F, Valcarce A, Straub U et al. J. Phys., 1993, **G19**: 2013

12 Obukhovsky I T, Kusainov A M. Phys. Lett., 1990, **B238**: 142

13 Kusainov A M, Neudatchin V G, Obukhovsky I T. Phys. Rev., 1991, **C44**: 2343

14 Buchmann A, Fernandez E, Yazaki K. Phys. Lett., 1991, **B269**: 35

15 Henley E M, Miller G A. Phys. Lett., 1991, **B251**: 453

16 HUANG F, ZHANG Z Y, YU Y W et al. Phys. Lett., 2004, **B586**: 69

17 Wildermuth K, TANG Y C. A Unified Theory of the Nucleus. Braunschweig: Vieweg, 1977

18 Kamimura M. Suppl. Prog. Theor. Phys., 1977, **62**: 236

19 Oka M, Yazaki K. Prog. Theor. Phys., 1981, **66**: 556

20 Straub U, ZHANG Z Y, Brauer K et al. Nucl. Phys., 1988, **A483**: 686

21 Arndt R A, Strakovsky I I, Workman R L et al. Phys. Rev., 1995, **C52**: 2120

22 Roper L D, Wright R M, Feld B T. Phys. Rev., 1965, **138**: B190

手征 $SU(3)$ 夸克模型研究低能 Nπ 散射相移*

黄飞[1,2;1)]　张宗烨[1]　余友文[1]

1 (中国科学院高能物理研究所　北京　100049)

2 (中国科学院研究生院　北京　100049)

摘要　在手征 $SU(3)$ 夸克模型中，通过求解共振群方程动力学地研究了同位旋 $I=1/2$ 和 $I=3/2$ 道 Nπ 的 S 波和 P 波低能弹性散射相移. 所用的模型参数由基态八重态和十重态重子的能量定出，并能给出不同分波的 KN 散射相移. 除了有明显共振态的道以外，计算得到的各个分波的 Nπ 散射相移和实验值定性一致.

关键词　Nπ 散射相移　夸克模型　手征对称性

2005 – 02 – 24 收稿，　2005 – 04 – 27 收修改稿

*国家自然科学基金(10475087)资助

1) E-mail: hfbin@mail.ihep.ac.cn