

NK and ΔK states in the chiral SU(3) quark model

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(Received 19 September 2004; published 27 December 2004)

The isospin $I=0$ and $I=1$ kaon-nucleon S , P , D , F wave phase shifts are studied in the chiral SU(3) quark model by solving the resonating group method (RGM) equation. The calculated phase shifts for different partial waves are in agreement with the experimental data. Furthermore, the structures of the ΔK states with $L=0$, $I=1$, and $L=0$, $I=2$ are investigated. We find that the interaction between Δ and K in the case of $L=0$, $I=1$ is attractive, which is not like the situation of the NK system, where the S -wave interactions between N and K for both $I=0$ and $I=1$ are repulsive. Our numerical results also show that when the model parameters are taken to be the same as in our previous NN and YN scattering calculations, the ΔK state with $L=0$ and $I=1$ is a weakly bound state with about 2 MeV binding energy, while the one with $I=2$ is unbound in the present one-channel calculation.

DOI: 10.1103/PhysRevC.70.064004

PACS number(s): 13.75.Jz, 12.39.-x, 21.45.+v

I. INTRODUCTION

In the framework of the constituent quark model, to understand the source of the constituent quark mass, spontaneous vacuum breaking has to be considered, and as a consequence the coupling between quark field and Goldstone boson is introduced to restore the chiral symmetry. In this sense, the chiral quark model can be regarded as a quite reasonable and useful model 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 system with strangeness [1]. This model has been quite successful in reproducing the energies of the baryon ground states, the binding energy of deuteron, the nucleon-nucleon (NN) scattering phase shifts of different partial waves, and the hyperon-nucleon (YN) cross sections by performing the resonating group method (RGM) calculations [1,2]. Recently this model has been extended to systems with antiquarks to study the baryon-meson interactions and meson-meson interactions. With the antiquark (\bar{q}) in the meson brought in, the complexity of the annihilation part in the interactions will appear. We started our study from the KN elastic scattering processes because in the KN system the annihilations to gluons and vacuum are forbidden and the $u(d)\bar{s}$ can only annihilate to kaon mesons. We calculated the KN phase shifts of S and P partial waves in the chiral SU(3) quark model and fortunately, we got quite reasonable agreement with the experimental data when the mixing between scalar mesons σ_0 and σ_8 is considered [3]. All of these achievements encourage us to extend our study to some higher partial waves of KN scattering and to some other 5 q systems with an antiquark \bar{s} , such as ΔK , NK^* , and so on.

Actually, the KN scattering process had aroused particular interest in the past [4–8] and many works have been devoted

to this issue based on the constituent quark model. But up to now, most of them cannot accurately reproduce the KN phase shifts up to $L=3$ in a sufficient consistent way. In this work we perform a RGM calculation of S -, P -, D -, and F - wave KN phase shifts in our chiral quark model. Comparing with other's previous work [7], a RGM calculation including σ and π boson exchanges, we obtain correct signs of S_{01} , P_{11} , P_{03} , D_{13} , D_{05} , F_{15} , and F_{07} waves, and for P_{01} , D_{03} , and D_{15} channels we also get a considerable improvement on the theoretical phase shifts in the magnitude.

About the structures of ΔK states, Sarkar *et al.* have made a study on a baryon level in their recent work [9], and they obtained a ΔK resonance state with $L=0$ and $I=1$ near the threshold. This state has also been investigated by Kolomeitsev and Luta in the χ -BS(3) approach [10]. In the present work we analyze the property of the one-gluon-exchange (OGE) interaction in ΔK states with $L=0$ and our results show that the OGE interaction is attractive for $I=1$ while repulsive for $I=2$. When the model parameters are taken to be the same as in our previous work which successfully reproduced the NN phase shifts and the YN cross sections [1,2], we find that the ΔK with $L=0$ and $I=1$ is a weakly bound state with a binding energy of about 2 MeV in our present one-channel calculation.

The paper is organized as follows. In the next section the framework of the chiral SU(3) quark model is briefly introduced. The results of KN phase shifts and ΔK states are shown in Sec. III, where some discussions are made as well. Finally, conclusions are given in Sec. IV.

II. FORMULATION**A. Model**

As is well known, the nonperturbative QCD effect is very important in light quark systems. To consider the low-

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momentum medium-range nonperturbative QCD effect, a SU(2) linear σ model [11,12] is supposed to study the NN interactions. 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 [1]. With this generalization, the interacting Hamiltonian between quarks and chiral fields can be written as

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

where g_{ch} is the coupling constant between the quark and chiral field, and λ_0 a unitary matrix. $\lambda_1, \dots, \lambda_8$ are the Gell-Mann matrix of the flavor SU(3) group, $\sigma_0, \dots, \sigma_8$ the scalar nonet fields, and π_0, \dots, π_8 the pseudoscalar nonet fields. $F(\mathbf{q}^2)$ is a form factor inserted to describe the chiral-field structure [13,14] and, as usual, it is taken to be

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

with Λ being the cutoff mass of the chiral field. Clearly, H_I^{ch} is invariant under the infinitesimal chiral SU(3) transformation.

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

$$V_{\sigma_a}(\mathbf{r}_{ij}) = -C(g_{ch}, m_{\sigma_a}, \Lambda) X_1(m_{\sigma_a}, \Lambda, r_{ij}) [\lambda_a(i) \lambda_a(j)] + V_{\sigma_a}^{ts}(\mathbf{r}_{ij}), \quad (3)$$

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

and

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

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

with

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

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

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

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

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

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

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

In the chiral SU(3) quark model, the interaction induced by the coupling of chiral fields describes the nonperturbative QCD effect of the low-momentum medium-distance range. To study the hadron structure and hadron-hadron dynamics, one still needs to include an effective one-gluon-exchange interaction V_{ij}^{OGE} which governs the short-range behavior,

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

with

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

and a confinement potential V_{ij}^{conf} to provide the nonperturbative QCD effect in the long distance,

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

For the systems with an antiquark \bar{s} , the total Hamiltonian can be written as [3]

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

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

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

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

$V_{i\bar{5}}$ in Eq. (16) includes two parts [3,15]: direct interactions and annihilation parts,

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

with

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

where

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

$$\begin{aligned} V_{i\bar{5}}^{OGE} = & \frac{1}{4}g_i g_s(-\lambda_i^c \cdot \lambda_5^{c*}) \left\{ \frac{1}{r_{i\bar{5}}} - \frac{\pi}{2} \delta(\mathbf{r}_{i\bar{5}}) \left(\frac{1}{m_q^2} + \frac{1}{m_s^2} \right. \right. \\ & \left. \left. + \frac{4}{3} \frac{1}{m_q m_s} (\boldsymbol{\sigma}_i \cdot \boldsymbol{\sigma}_s) \right) \right\} - \frac{1}{16} g_i g_s \\ & \times (-\lambda_i^c \cdot \lambda_5^{c*}) \frac{3}{m_q m_s} \frac{1}{r_{i\bar{5}}} \mathbf{L} \cdot (\boldsymbol{\sigma}_i + \boldsymbol{\sigma}_s), \end{aligned} \quad (22)$$

and

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

Here $(-1)^{G_j}$ represents the G parity of the j th meson. For the NK and ΔK systems, $u(d)\bar{s}$ can only annihilate into a kaon meson—i.e.,

$$V_{i\bar{5}}^{ann} = V_{ann}^K, \quad (24)$$

with

$$\begin{aligned} V_{ann}^K = & C^K \left(\frac{1 - \boldsymbol{\sigma}_q \cdot \boldsymbol{\sigma}_{\bar{q}}}{2} \right)_s \left(\frac{2 + 3\lambda_q \cdot \lambda_{\bar{q}}^*}{6} \right)_c \\ & \times \left(\frac{38 + 3\lambda_q \cdot \lambda_{\bar{q}}^*}{18} \right)_f \delta(\mathbf{r}), \end{aligned} \quad (25)$$

where C^K is treated as a parameter and we adjust it to fit the mass of kaon meson.

B. Determination of the parameters

We have three initial input parameters: the harmonic-oscillator width parameter b_u , the up (down) quark mass $m_{u(d)}$, and the strange quark mass m_s . These three parameters are taken to be the usual values: $b_u=0.5$ fm, $m_{u(d)}=313$ MeV, and $m_s=470$ MeV. By some special constraints, the other model parameters are fixed in the following way. The chiral coupling constant g_{ch} is fixed by

TABLE I. Model parameters. The meson masses and the cutoff masses: $m_{\sigma'}=980$ MeV, $m_{\kappa}=980$ MeV, $m_{\epsilon}=980$ MeV, $m_{\pi}=138$ MeV, $m_{\kappa}=495$ MeV, $m_{\eta}=549$ MeV, $m_{\eta'}=957$ MeV, and $\Lambda=1100$ MeV.

	NN, YN cases		KN case	
		$\theta^S=35.264^\circ$	$\theta^S=-18^\circ$	
b_u (fm)	0.5	0.5	0.5	
m_u (MeV)	313	313	313	
m_s (MeV)	470	470	470	
g_u	0.886	0.886	0.886	
g_s	0.917	0.917	0.917	
$m_{\sigma'}$ (MeV)	595	675	675	
a_{uu}^c (MeV/fm ²)	48.1	52.4	55.2	
a_{us}^c (MeV/fm ²)	60.7	72.3	68.4	
a_{uu}^{c0} (MeV)	-43.6	-50.4	-55.1	
a_{us}^{c0} (MeV)	-38.2	-54.2	-48.7	

$$\frac{g_{ch}^2}{4\pi} = \left(\frac{3}{5} \right)^2 \frac{g_{NN\pi}^2 m_u^2}{4\pi M_N^2}, \quad (26)$$

with $g_{NN\pi}^2/4\pi=13.67$ taken as the experimental value. The masses of the mesons are also adopted to the experimental values, except for the σ meson, where its mass is treated as an adjustable parameter. In our previous work it is taken to be 595 MeV [2] for the NN and YN cases while 675 MeV for the present KN case. The cutoff radius Λ^{-1} is taken to be the value close to the chiral symmetry breaking scale [13,14,16,17]. After the parameters of chiral fields are fixed, the one-gluon-exchange coupling constants g_u and g_s can be determined by the mass splits between N , Δ and Σ , Λ , respectively. The confinement strengths a_{uu}^c , a_{us}^c , and a_{ss}^c are fixed by the stability conditions of N , Λ , and Ξ and the zero-point energies a_{uu}^{c0} , a_{us}^{c0} , and a_{ss}^{c0} by fitting the masses of N , Σ , and $\Xi+\Omega$, respectively.

In the calculation, η and η' mesons are mixed by η_1 and η_8 with the mixing angle θ^{PS} taken to be the usual value -23° . For the KN case, we also consider the mixing between σ_0 and σ_8 . The mixing angle θ^S is still an open issue because the structure of σ meson is unclear and controversial. We adopt two possible values by which we can get reasonable KN phase shifts. One is 35.264° which means that σ and ϵ are ideally mixed by σ_0 and σ_8 , and the other is -18° which is provided by Dai and Wu [18] based on their recent investigation.

The three sets of model parameters are tabulated in Table I. The first column is for the case fitted by NN and YN scattering, and the second and third columns are for the case fitted by KN scattering. For each set of parameters the octet and decuplet baryons' masses can be well reproduced in our model [3,19].

III. RESULTS AND DISCUSSIONS

A. KN phase shifts

A RGM dynamical calculation of the S -, P -, D -, and F -wave KN phase shifts with isospin $I=0$ and $I=1$ is made,

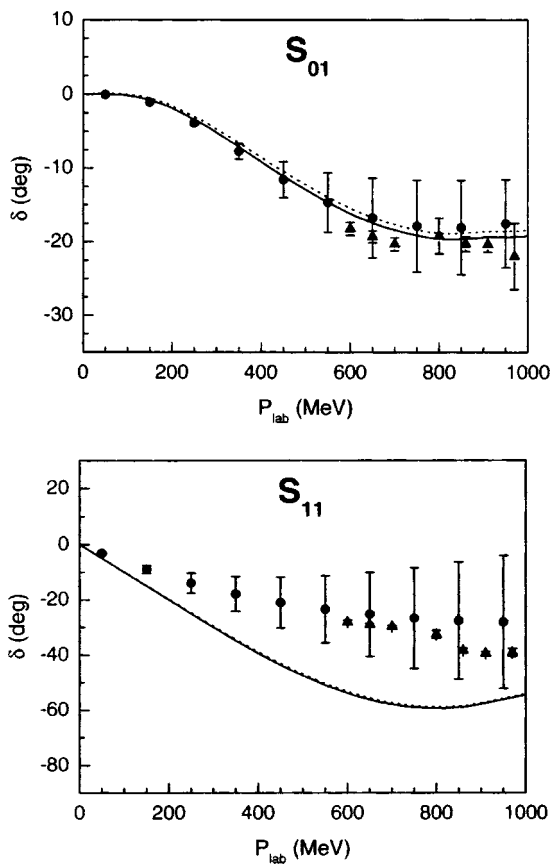


FIG. 1. KN S -wave phase shifts as a function of the laboratory momentum of kaon meson. The hole circles and the triangles correspond respectively to the phase shifts analysis of Hyslop *et al.* [20] and Hashimoto [21].

and the numerical results are shown in Figs. 1–4. Here we use the conventional partial wave notation: the first subscript denotes the isospin quantum number and the second one twice of the total angular momentum of the KN system. The solid lines represent the results obtained by considering $\theta^S = 35.264^\circ$ while the dotted lines -18° .

Actually, some authors have studied the KN scattering processes on a quark level. One recent work [7] —a RGM calculation including σ and π boson exchanges—gave an opposite sign of the S_{01} channel phase shifts. And another previous work based on the constituent quark model concluded that a consistent description of both isospin S -wave channels is not possible [22]. From Fig. 1 one can see that we obtain the right sign of the S_{01} channel phase shifts, and our results are in agreement with the experimental data for both isospin $I=0$ and $I=1$ channels, although for S_{11} they are a little repulsive.

For higher-angular-momentum results (Figs. 2–4), comparing with the recent RGM calculation of Lemaire *et al.* [7], we now get correct signs of P_{11} , P_{03} , D_{13} , D_{05} , F_{15} , and F_{07} waves, and for P_{01} , D_{03} , and D_{15} channels we also obtain a considerable improvement on the theoretical phase shifts in the magnitude. We also compare our results with those of the previous work of Black [5]. Although our calculation achieves a considerable improvement for all partial waves, the results of the P_{13} channel are too repulsive in both

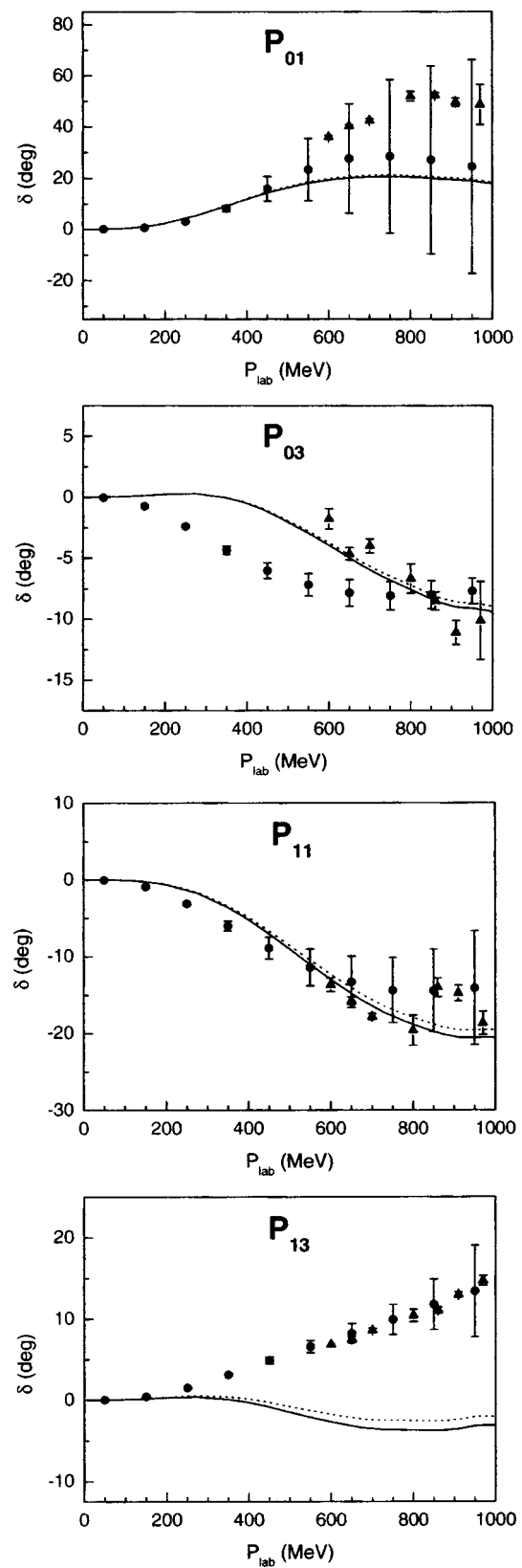


FIG. 2. KN P -wave phase shifts. Same notation as in Fig. 1.

Black’s work and our present one. The effects of the coupling to the inelastic channels and hidden color channels are expected to be considered in future work.

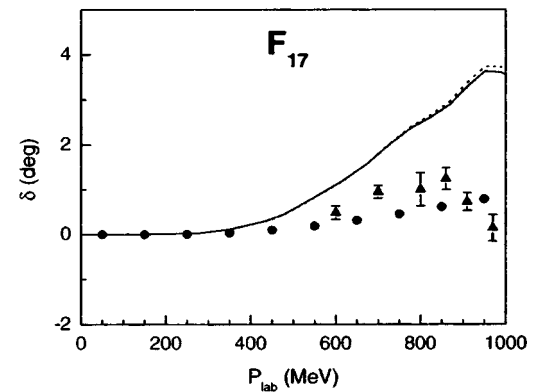
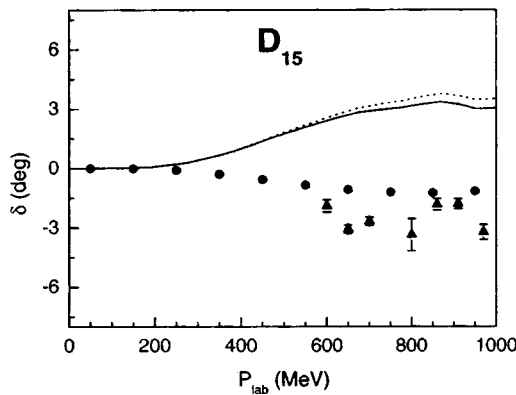
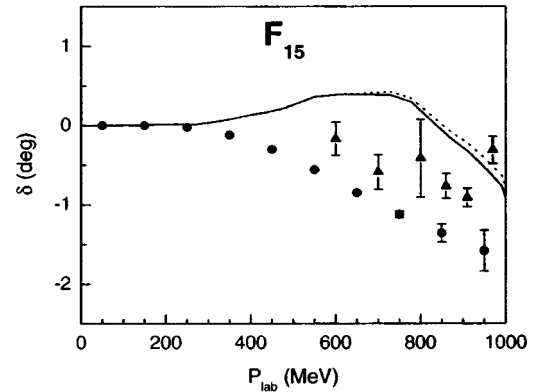
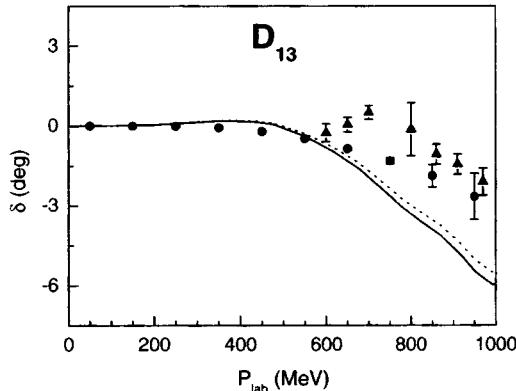
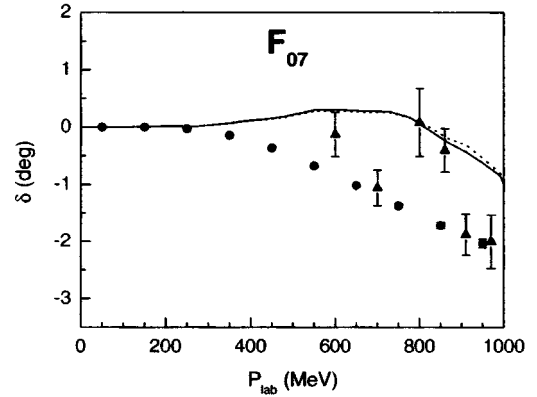
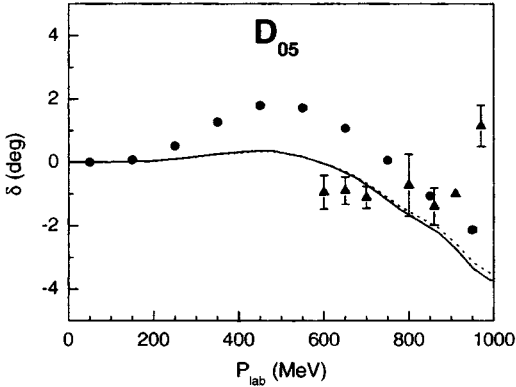
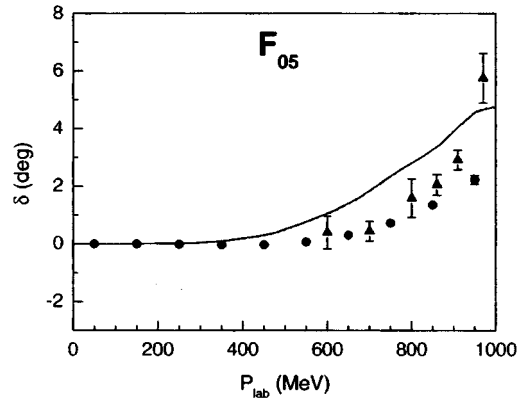
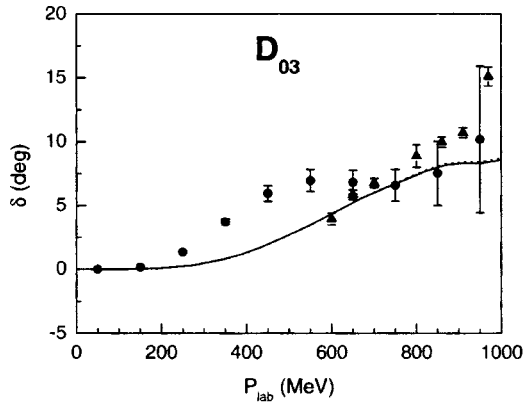


FIG. 3. KN D -wave phase shifts. Same notation as in Fig. 1.

FIG. 4. KN F -wave phase shifts. Same notation as in Fig. 1.

Since the annihilation interaction is not clear, its influence on the phase shifts should be examined. We omitted the annihilation part entirely to see its effect and found that the numerical phase shifts only have very small changes.

This is because in the KN system the annihilations to gluons and vacuum are forbidden and $u(d)\bar{s}$ can only annihilate to a kaon meson. This annihilation part originating from the S channel acts in the very short range, so

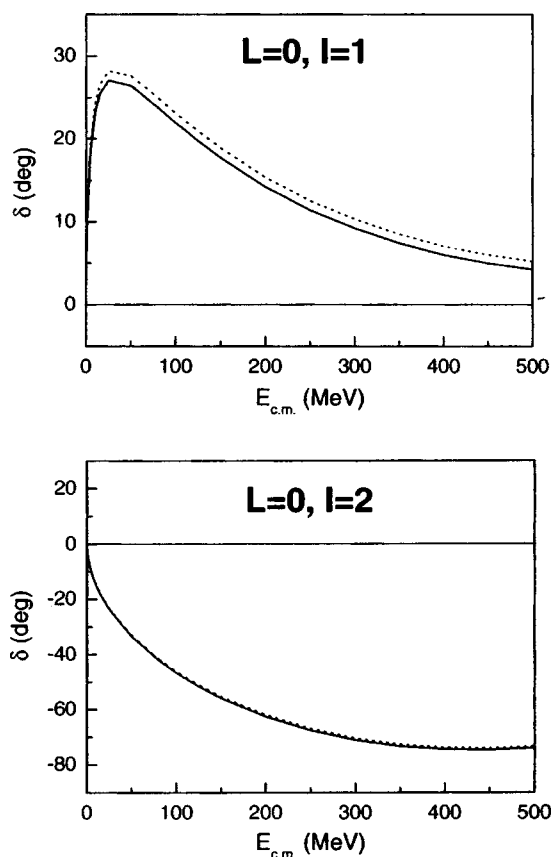


FIG. 5. ΔK S -wave phase shifts as a function of the energy of the center of mass motion. The solid lines represent the results obtained by considering $\theta^\delta=35.264^\circ$ while the dotted lines -18° .

that it plays a nonsignificant role in the KN scattering process.

From the above discussion, one sees that our theoretical S -, P -, D -, and F -wave KN phase shifts are all reasonably consistent with the experimental data. In this sense we can conclude that our chiral $SU(3)$ quark model can also be applied for the KN system in which an antiquark \bar{s} is there besides four $u(d)$ quarks. Moreover, some information of the quark-quark and quark-antiquark interactions has been obtained which is useful for developing this model to study the other hadron-hadron systems.

B. ΔK states

In Ref. [9] a ΔK resonance state with $L=0$ and $I=1$ has been obtained near the threshold. In the present work we perform a RGM dynamical calculation to study the structures of ΔK states in the framework of our chiral $SU(3)$ quark model.

First we calculated the S -wave ΔK phase shifts using two sets of parameters fitted by the KN phase shifts calculations, although there is no experimental data to be compared. The results are shown in Fig. 5, from which we can see that the phase shifts are positive for the isospin $I=1$ channel while negative for $I=2$. This means that the interaction between Δ and K is attractive in the $L=0, I=1$ state and repulsive in the

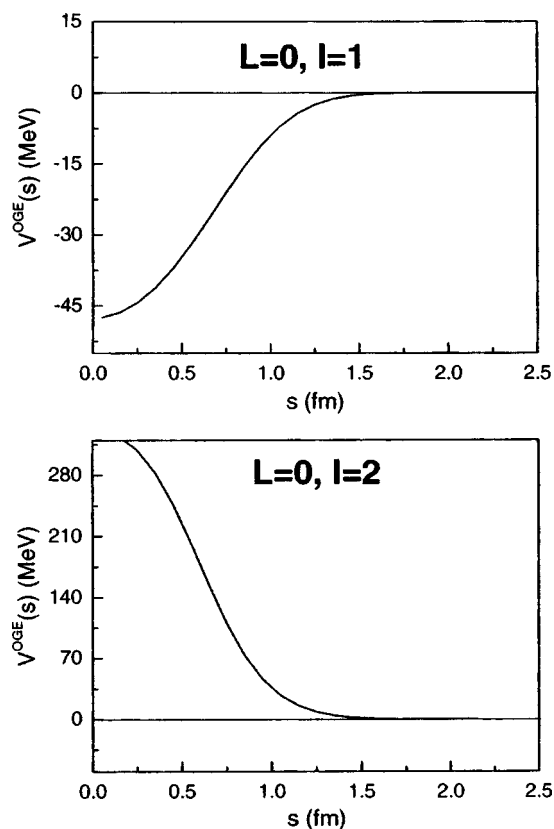


FIG. 6. The GCM matrix elements of OGE.

$L=0, I=2$ state. Although in our calculations there is no obvious $I=1$ ΔK resonance state, the ΔK $L=0, I=1$ state is really an interesting case, because it has an attractive interaction, and when some other effects, such as coupling channel effect, are considered, it might be a resonance or even a bound state.

We did an analysis to see the contributions from different parts of the interactions in the ΔK states. Figure 6 shows the diagonal matrix elements of the one-gluon-exchange potential in the generator coordinate method (GCM) calculation [23], which can describe the interaction between two clusters Δ and K qualitatively. In Fig. 6, s denotes the generator coordinate and $V^{OGE}(s)$ is the OGE effective potential between the two clusters. One sees that the one-gluon-exchange potential is attractive for $I=1$ while strongly repulsive for $I=2$. This means that the OGE interaction plays an important role in the ΔK system.

In our calculation, the tensor force is also included. Since the kaon meson is spin zero, the tensor force of pion exchange, which plays an important role in reproducing the binding energy of deuteron [2], now nearly vanishes and the nondiagonal matrix elements between S waves and D waves offer pinging contributions to the ΔK system.

To study the existence of a resonance or a bound state of the ΔK system, we solve the RGM equation for the bound state problem. The results show that if the parameters are taken to be the values fitted by KN phase shifts, the ΔK states are unbound for both $I=1$ and $I=2$, though the ΔK state with $L=0$ and $I=1$ has attractive interaction. However when we take those parameters determined by the nucleon-nucleon

phase shifts of different partial waves and the hyperon-nucleon cross sections, we get a weakly bound state of ΔK with about 2 MeV binding energy for $I=1$ while unbound for $I=2$ in the present one-channel calculation. Certainly the channel coupling between $(\Delta K)_{LSJ=0,3/2,3/2}$ and $(NK^*)_{LSJ=0,3/2,3/2}$ should be considered further, because the effect of quark exchange between these two channels is remarkable. It is expected that the energy of the ΔK $L=0$ and $I=1$ state will be decreased once the channel coupling is considered.

Here we would like to mention that our results of both KN phase shifts and ΔK states are independent of the confinement potential in the present one-channel two-color-singlet-cluster calculation. Thus our numerical results will almost remain unchanged even the color quadratic confinement is replaced by the color linear one.

IV. CONCLUSIONS

In this paper, the chiral SU(3) quark model has been extended to the system with an antiquark, and the S -, P -, D -, and F -wave KN phase shifts have been studied by solving the resonating group method equation based on this model. Comparing with another RGM calculation [7], we can obtain correct signs of S_{01^-} , P_{11^-} , P_{03^-} , D_{13^-} , D_{05^-} , F_{15^-} , and F_{07^-} -wave phase shifts and a considerable improvement on

the theoretical phase shifts in the magnitude for P_{01} , D_{03} , and D_{15} channels. It turns out that our chiral SU(3) quark model is quite successful to be extended to study the KN system, in which an antiquark \bar{s} is there besides four $u(d)$ quarks. At the same time some useful information of quark-quark and quark-antiquark interactions is provided.

Also, we have studied the ΔK systems using our model. If the parameters are taken to be the values fitted by KN phase shifts, the S -wave ΔK states for both $I=1$ and $I=2$ are unbound, though the interaction between Δ and K is attraction for the $I=1$ state. However, when we take the parameters determined by the NN phase shifts and the YN cross sections, we find that there is a weakly ΔK bound state with $L=0$ and $I=1$, and the binding energy is about 2 MeV in our present one-channel calculation.

To examine if $(\Delta K)_{LSJ=0,3/2,3/2}$ is possible to be a resonance or a bound state, the channel coupling between $(\Delta K)_{LSJ=0,3/2,3/2}$ and $(NK^*)_{LSJ=0,3/2,3/2}$ would be considered in our future work.

ACKNOWLEDGMENTS

One of the authors (F.H.) is indebted to Prof. Y.B. Dong and Dr. D. Zhang for a careful reading of the manuscript. This work was supported in part by the National Natural Science Foundation of China, Grant No. 90103020.

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