# Effect of Confined One Gluon Exchange and One - Pion Exchange on Nucleon - Nucleon Interaction

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## Introduction

Effects of confined gluons in understanding the hadron hadron interaction has been studied successfully [1]. The One Pion Exchange Potential (OPEP) has been used to study N-N interaction to obtain the partially conserved axial current as it is important to know the contribution of OPEP to the N-N potential [3]. In the present investigation, the well known RGM technique in the framework of RQM will be used to investigate the N-N adiabatic potential for the $^1S_0$ and $^3S_1$ states using Born-Oppenheimer approximation. The role played by OPEP to the adiabatic potential will also be studied.

## Model

The full Hamiltonian used here is

$$H = K + V_{int} + V_{conf} - K_{CM} \tag{1}$$

where $K$ is the kinetic energy, $V_{int}$ is the interaction potential term, $V_{conf}$is the harmonic confinement potential and $K_{CM}$ is the kinetic energy of the centre of mass. The interaction potentials considered here are COGEP and OPEP.

The Confined Gluon Propagators (CGP) derived from a Current Confinement Model (CCM) are used to derive the COGEP [1]. The central part of the COGEP is given by

$$\tilde{V}_{COGEP} = \frac{\alpha_s N^4}{4}\boldsymbol{\lambda}_i.\boldsymbol{\lambda}_j[D_0(\boldsymbol{r}) + \frac{1}{(E+M)^2} \times[4\pi\delta^3(\boldsymbol{r}) - c^4r^2D_1(\boldsymbol{r})][1-\frac{2}{3}\boldsymbol{\sigma}_i.\boldsymbol{\sigma}_j]] \tag{2}$$

where

$$\frac{\alpha_s N^4}{4}\boldsymbol{\lambda}_i.\boldsymbol{\lambda}_j[D_0(\boldsymbol{r}) + \frac{1}{(E+M)^2}(4\pi\delta^3(\boldsymbol{r}) - c^4r^2D_1(\boldsymbol{r}))]$$

is the color electric part of the COGEP and

$$\frac{\alpha_s N^4}{4}\boldsymbol{\lambda}_i.\boldsymbol{\lambda}_j[\frac{1}{(E+M)^2}(4\pi\delta^3(\boldsymbol{r}) - c^4r^2D_1(\boldsymbol{r})) \times(1-\frac{2}{3}\boldsymbol{\sigma}_i.\boldsymbol{\sigma}_j)]$$

is the color magnetic part of the COGEP.

$\alpha_s$ is the strong coupling constant. $\boldsymbol{\lambda}_i$ and $\boldsymbol{\lambda}_j$ are the generators of the color SU(3) group for the $i^{th}$ and $j^{th}$ quarks, $\boldsymbol{\sigma}_i$ and $\boldsymbol{\sigma}_j$ are the Pauli spin operators.

The OPEP [3] is given by

$$V_{OPEP} = \frac{f_Q^2}{3}\sum_{i<j}\frac{e^{-m_\pi r_{ij}}}{r_{ij}}(\boldsymbol{\sigma}_i.\boldsymbol{\sigma}_j)(\boldsymbol{\tau}_i.\boldsymbol{\tau}_j) \tag{3}$$

where $\boldsymbol{\sigma}_i$ and $\boldsymbol{\sigma}_j$ are the Pauli spin operators of the $i^{th}$ and the $j^{th}$ quarks and $\boldsymbol{\tau}_i$ and $\boldsymbol{\tau}_j$ are the isospins of the $i^{th}$ and the $j^{th}$ quarks. $f_Q$ is the OPEP strength parameter and is related to the pion - nucleon coupling constant by the relation $f_Q^2 = \frac{f_{\pi NN}^2}{4\pi}$ [4].

## Results and Discussion

In COGEP, the exchange kernels of $\delta(\boldsymbol{r})$ dominate over the exchange kernels of $c^4r^2D_1(\boldsymbol{r})$ at short range distances, which provides the short range repulsion. The exchange kernels of $c^4r^2D_1(\boldsymbol{r})$ dominate over the exchange kernels of $\delta(\boldsymbol{r})$ at intermediate and long ranges. This provides the long range attraction. It is seen that the any important role in N-N interaction is not played by the

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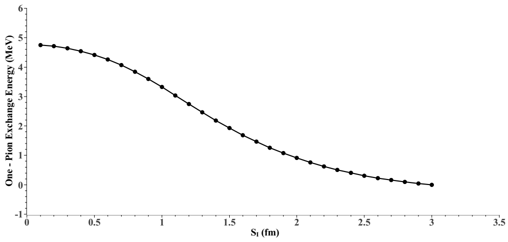


FIG. 1: Total OPEP energy

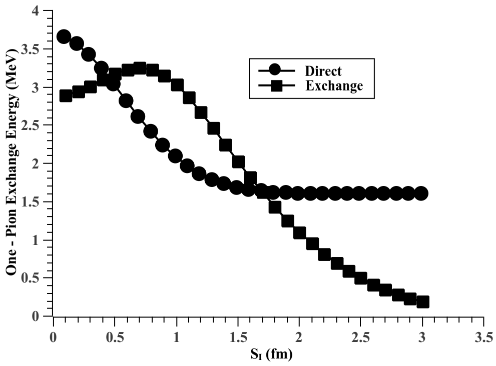


FIG. 2: Direct and Exchange parts of the OPEP energy

confinement potential of the quarks and the color electric terms in the COGEP [2].

The contribution of the OPEP is plotted in fig. 1. The corresponding direct and exchange components are plotted in fig. 2. It is observed that, in the short range, both direct and exchange part of OPEP give rise to independent repulsion. Hence, in the short range, the total contribution of the OPEP is repulsive in nature [5].

Further investigation will be carried out to study the N-N adiabatic potential with COGEP and OPEP.

## References

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