REVIEW OF INTERACTION CONSTANT OF VECTOR MESON-NUCLEON IN THE FRAMEWORK OF AdS/QCD HARD WALL MODEL

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In the framework of AdS/QCD hard wall model ρ meson-nucleon interaction constant is calculated by us. Langrangian interaction is used between spinor, vector and pseudo-scalar fields in the internal part of AdS space. Using AdS/QCD correspondence principle the integral expression for meson-nucleon interaction constant is obtained and its numerical value is calculated.

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INTRODUCTION

Last time the study of elementary cells in AdS/QCD models presents the big inteterst in theoretical physics.

The AdS/QST duality idea is formed from supersymmetric theory. The supersymmetric theory combines 4 fundamental interactions: gravitational, electromagnetic, weak and strong ones. This duality requires the equivalence of 2 below mentioned theories: the theory of 4-dimensional calibration and the theory of 5-dimensional AdS space-gravitation.

Gauge theory describes the other interaction forces: electromagnetic, weak and strong ones excluding the gravitation forces. For example, *U(1)* electromagnetic and *SU(3)* strong interactions are described by Gauge theory (this theory is called quantum chromodynamics, QCD).

De-Sitter space is the solution of constant positive Einstein curve. AdS (anti- De-Sitter space) is constant negative curve of time space. AdS/QST compatibility forms the connection between 4- and 5-dimensional physics. This theory is callede gollographic one.

The interaction of elementary cells is calculated by 2 AdS/QST models. The hard wall model in this model sets the boundary conditions at the points 0 and z_m at z spatial variable and thus, the theory in limit region is established.

The additional region called Dilaton $D(z)=\lambda^2 z^2$ multiplied on $e^{D(z)}$ Langrangian limit is added to soft wall model.

The meson-nucleon interaction is studied in this article on the base of AdS/QCD hard wall model. This problem has been considered in the previous articles [4,7,8]. However, the gluon condensate in these cases isn't considered in X pseudoscalar region. The constant coefficient ρNN defined in the work [1] is recalculated by X field application.

HARD WALL MODEL

The interaction expression in hard wall model is given bellow and changes in interval:

$$S_{q/t}(V(q,z)) = \int d^4x\, dz\sqrt{g}\,\mathcal{L}_{q/t} \qquad (1)$$

$g=|detg_{MN}|$ (M,N =0,1,2,3,5) changes at interval $0 \le z \le z_m$. $\mathcal{L}_{q/t}$ is Langrangian interaction between vector and fermionic fields inside AdS space. AdS space metric is given in Poincare coordinates:

$$ds^2 = \frac{1}{z^2}\left(-dz^2 + \eta_{\mu\nu}dx^\mu dx^\nu\right)$$

$\eta_{\mu\nu}$ is 4D Minkovski metric

$$\eta_{\mu\nu} = \mathrm{diag}(1,-1,-1,-1).$$

The pseudoscalar field X is added in theory of golographic duality inside AdS space $SU(2)_L \times SU(2)_R$ besides vector and fermionic fields with the aim of providing of chiral symmetry breakaging by Higgz mechanism.

$$S_{5D} = \int d^4x \int dz\sqrt{G}\,Tr[|DX|^2 + 3X^2)]$$

Here,$|DX|^2 = (D_M X)^\dagger (D^M X)$, $D_M X$ is covariant variative and is defined by following way:

$$D_M X = \partial_M X - iL_M X + iR_M X.$$

The asymptotic solution for X in $z \to 0$ value is given below:

$$X(z) \approx \frac{1}{2}am_q z + \frac{1}{2a}\sigma z^3 = v(z). \qquad (2)$$

Here m_q and d are quark aggregation and σ is chiral condensate value. m_q and σ are fixed in the result of solution of ultraviolet and IR limits according to pseudoscalar region X. mq = 0.0083 GeV , σ = (0.213)3 GeV3 and $a = \mathrm{Nc}/(2\pi)$ [1].

The following expression:

$$f_{1L}^n = c_1^n z^{\frac{5}{2}} \mathcal{J}_2(pz),\ f_{1R}^n = c_1^n z^{\frac{5}{2}}\mathcal{J}_3(pz),$$
$$f_{2L}^n = -c_2^n z^{\frac{5}{2}}\mathcal{J}_3(pz),\ \ f_{2R}^n = c_2^n z^{\frac{5}{2}}\mathcal{J}_2(pz). \quad (3)$$

is described in work [7] for nucleon profil function in hard wall model. In (3) formula the normalization constants

$$\int_0^{z_m} \frac{dz}{z^5} f_{1L}^{(n)}(z) f_{1L}^{(m)}(z) = \delta_{nm}\,, \qquad (4)$$

and in (4) formula the obtained normalization conditions are given below:

$$|c_{1,2}^n| = \frac{\sqrt{2}}{z_m \mathcal{J}_2(m_n z_m)}. \qquad (5)$$

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INTERNAL INTERACTION CONSTANT AND $g_{\rho NN}$ MESON-NUCLEON INTERACTION

According to AdS/QSD the formation inside 4D in QSD in functional 5D space AdS_5 is defined by following way:

$$Z_{KXD}(V_\mu^0) = e^{iS_{q/t}(\tilde{V}_\mu(q,z))} \tag{6}$$

Here $\tilde{V}_\mu^0(q,z)$ is vector field in 5D AdS space;

$\tilde{V}_\mu^0 = \tilde{V}_\mu(q,z=0) = V_\mu(q)$

is 5D space value $\tilde{V}_\mu^0(q,z) = V_\mu^0(q)V(q,z)$ of $(V(q,z=0)=1)$ vector field. By other hand, it is known that AdS functionality of 4D vector current converter for nucleons in space boundary is equal to functional converter according vacuum unite of 4D field in ultraviolet boundary.

$$< J_\mu >= -i\frac{\delta Z_{KXD}}{\delta \tilde{V}_\mu^0}|_{\tilde{V}_\mu^0=0} \tag{7}$$

Here J_μ being the vector current for nucleons at ρ meson-nucleon interaction is expressed by following way (8):

$$J_\mu(p',p) = g_{\rho NN}\bar{u}(p')\gamma_\mu u(p) \tag{8}$$

$\tilde{V}_\mu^0$ is current source for J_μ. The bond of impulse conservation energy: $q = p' - p$ is between 4D impulses. Here p' and p are impulses before and after interaction between spinor and vector fields inside AdS space. p' and p are impulses of initial and final 4D nucleon in QSD theory. 5D interaction (1) characterizing the interaction between vector and fermion fields inside AdS space is used for calculation of interaction ρNN constant meson-nucleon. The expression of Langrangian interaction in an unfolded form should be given in (1). The given Langrangian expression is obtained according to calibration invariancy of the model used by us.

$$\mathcal{L}_{\rho NN}^{(0)} = \bar{N}_1 e_A^M \Gamma^A V_M N_1 + \bar{N}_2 e_A^M \Gamma^A V_M N_2. \tag{9}$$

Here, N_1 and N_2 are 5D Dirac fermion fields and take under consideration the $SU(2)_L \times SU(2)_R$ chiral calibration group, they transform into (2,1) and (1,2). e_A^M being Weylbeyn transition from curvilinear space to rectilinear one, is defined by $e_M^A = \frac{1}{z}\eta_M^A$. V_M defines the vector field and Γ^A being the matrix of 5D Dirak fermion field, is defined by $\Gamma^A = (\gamma^\mu, -i\gamma^5)$.

$$\Gamma^5 = -i\gamma^5 = \begin{pmatrix} -i & 0 \\ 0 & i \end{pmatrix}, \Gamma^0 = \begin{pmatrix} 0 & -1 \\ -1 & 0 \end{pmatrix}, \Gamma^i = \begin{pmatrix} 0 & \sigma^i \\ -\sigma^i & 0 \end{pmatrix}, \text{(i=1,2,3)}.$$

Taking under consideration the current expression in (8), Langrangian interaction in (9) gives to the constant of $g_{\rho NN}$ meson-nucleon vector the following formula:

$$g_{\rho NN}^{(0)nm} = \int_0^{z_m}\frac{dz}{z^4}V_0(z)\left(f_{1L}^{(n)*}(z)f_{1L}^{(m)}(z) + f_{2L}^{(n)*}(z)f_{2L}^{(m)}(z)\right). \tag{10}$$

$V_0(z) = (kz)^2\sqrt{2}L_0^{(1)}(k^2z^2)$ is profile function of Caluza-Klein mode vector field, $f_{1L}^{(n)}$ *və* $f_{1R}^{(m)}$ are nucleon profile functions. The profile functions for nucleons have been already given in equation (3). The spinors inside 5D AdS space have the magnetic moment. By this reason, they interact with vector field with the help of magnetic moment. According to this interaction, Langrangian is obtained by 4D theory and has the following form:

$$\mathcal{L}_{FNN}^{(1)} = ik_1 e_A^M e_B^N(\bar{N}_1\Gamma^{AB}(F_L)_{MN}N_1 - \bar{N}_2\Gamma^{AB}(F_R)_{MN}N_2) \tag{11}$$

Here, i is a complex unit, k_1 is constant coefficient, e_A^M and e_B^N being вeing Weyl bey transition from curvilinear space to rectilinear one, is defined by $e_M^A = \frac{1}{z}\eta_M^A$. N_1 and N_2 are 5D Dirac fermion fields. $\Gamma^{MN}F_{MN}$ matrixes consist of the sum of two boundaries $F^{5v}F_{5v}$ and $\Gamma^{\mu\nu}F_{\mu\nu}$. Using Langrangian interaction $L_{FNN}^{(1)}$, gives to the constant of $g_{\rho NN}$ meson-nucleon vector the following formula:

$$g_{\rho NN}^{(1)nm} = -2\int_0^\infty\frac{dz}{z^3}e^{-k^2z^2}V_0^`(z)[k_1\left(f_{1L}^{(n)*}(z)f_{1L}^{(m)}(z) - f_{2L}^{(n)*}(z)f_{2L}^{(m)}(z)\right) + k_2\,v(z)\left(f_{1L}^{(n)*}(z)f_{2L}^{(m)}(z) + f_{2L}^{(n)*}(z)f_{1L}^{(m)}(z)\right)]. \tag{12}$$

NUMERICAL CALCULATIONS

Thus, two integral expressions (10) and (12) are obtained in AdS/QSD hard wall model for $g_{\rho NN}$ interaction constant of ρ meson-nucleon. The final interaction constant is the sum of two expressions:

$$g_{\rho NN}^{s.d.} = g_{\rho NN}^{(0)nm} + g_{\rho NN}^{(1)nm}. \tag{13}$$

The unit calculations (13) are calculated with the help of MATHEMATICA program. $a = 0.2757$ is calculated for A constant in *SU(2)* symmetry. The following units: m_n=0.94 (GeV), σ =(0.213)^3 GeV^3, m_q=0.0083 GeV, k_1=-0.98 GeV^3 , $k_2 = 0.5\ GeV^3$are used for parameter sum. Taking under consideration these constant values we obtain the final calculation $g_{\rho NN}^{s.d.}$ =0,078.

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