## DIRAC FORM FACTOR OF THE TRANSITION IN THE HARD-WALL AdS/QCD MODEL

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**ABSTRACT**

We define Dirac form factor transition for N\* with negative parity within hard-wall AdS/QCD model. Using AdS/CFT correspondence between generating functions in the bulk and boundary theories, we obtain an expression for the Dirac form factor from the bulk interaction action. We plot the form factor dependence from the transferred momentum square using MATHEMATICA package.

**`Keywords:** AdS/CFT correspondence, Roper nucleon, form factor.

## INTRODUCTION

## The study of electromagnetic properties of Roper resonance, open new opportunities for understanding the structure of hadrons. Nucleon resonances have been discussed in the soft-wall AdS /QCD model, Light Front holography,covariant spectator quark model in Refs. [1,3-5]. In Ref. [1] authors apply the Light Front holography in the soft wall approximation to the study of the electromagnetic structure of the nucleon and nucleon excitations. In Ref. [2] authors predict the transition form factors and the helicity amplitudes using covariant spectator quark model for have also been discussed in the AdS soft-wall approach at finite temperature in Ref. [6]. In this work, we discuss transition Dirac form factor for N\* with negative parity within hard-wall AdS/QCD model.

## The article is organized as follows. In Sec. II we briefly review the hard-wall model in AdS/QCD. In Sec. III we present a vector field in the AdS space. In Sec. IV we calculate and discuss the Dirac form factor for the reaction. Finally, in Sec. V we present our numerical result for this form factor .

**THE HARD-WALL MODEL OF ADS/QCD**

In this section, we present profile functions for a nucleon in the framework of the hard-wall AdS/QCD model. The bulk action for a Dirac spinor (and similarly for ) is written:

 , (2.1)

where, is the vielbein, is the mass of the bulk spinor, have defined with the properties , and *(A=0,1,2,3,5)*  are the the Dirac matrices. The gauge and Lorentz-covariant derivative is defined as:

 (2.2)

Here is spin connection [3, 7] and its non-vanishing components are given by:

 (2.3)

Taking a variation from the (2.1) action with respect to and applying the least action principle, one obtains a following equation with the boundary conditions:

 (2.4)

 (2.5)

Fourier-transform of the bulk spinor is:

 (2.6)

where obey 4D Dirac equation

 (2.7)

And satisfy equations over the variable [8]:

 (2.8)

 (2.9)

Eliminating from the (2.8) and (2.9) equations the equation for the profile function can be found:

 (2.10)

Similarly, we have for the profile function:

. (2.11)

Near the UV boundary, , the profile functions are given by [3,8]:

 (2.12)

 (2.13)

 are the normalization constants, which was found in [4] and are equal to:

 . (2.14)

The normalizable solutions for nonzero modes are given by:

1. **VECTOR FIELD IN ADS SPACE**

The action in the five-dimensional AdS space for vector field will be written as follows:

 (3.1)

where, is the determinant of metric tensor , is related to the number of colors , is vector field strength tensor. Transverse part of vector field will be written as and the equation of motion obtained from the (3.1) action gives an equation for the profile function [5]:

 (3.2)

The (3.2) equation will be solved under the and ultraviolet (UV) and infrared (IR) boundary conditions, respectively. Solution is expressed in terms of the first kind Bessel functions:

. (3.3)

## DIRAC FORM FACTOR OF THE TRANSITION

## In general, the action for interaction is written as follows:

 (4.1)

where, is the interaction Lagrangian and it is given by following terms [5]:

 (4.2)

 (4.3)

Here is the set of parameters, which mix the contributions of the AdS fermion fields with the different twist dimension, is defined as:, is the Pauli matrix, .

 According to AdS/CFT correspondence, the action for the four-dimensional field theory is equal to the classical action for the five-dimensional AdS theory [10,11]:

 (4.4)

The vacuum expectation of the nucleon’s vector current can be defined by taking variation from the generating functional of the bulk theory:

The electromagnetic transition between nucleon and resonance can be described by the current [4]:

 (4.6)

where, , are Dirac spinors, , , are called Dirac and Pauli form factors, respectively. Dirac form factor will be found from the comparison of the two currents (4.5) and (4.6):

 (4.7)

and have an expression:

**|**

**CONCLUSIONS**

As was noted in the introduction, the reaction was studied within several models[17]. In the present work, we apply the AdS/CFT holography in the hard wall approximation to the study of the electromagnetic structure of the nucleon and nucleon excitations. Our numerical results for the transition Dirac form factor is presented in Fig.1.

Finally, the free parameter are fixed as:

, ,

 , .

We also include CLAS [13], MAID [14,15] and JLab/Hall C [16] experimental data for a comparison in Fig.2. Our result is compatible with experimental data in the region .



**FIG. 1**: reaction Dirac form factor

 0.4

 0.3

F1 (Q2)

 0.2

 0.1

 0 1 2 3 4 5 6 7 8

 (Q2) (GeV2)

**FIG. 2:** Results for the transition form factors given by the semirelativistic appoximation.(thick solid line) [17]. Data from CLAS [13] (full circles), MAID [14,15] (full squares), JLab/Hall C [16] (triangles).

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