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Born–Infeld extension of Lovelock brane gravity in the system of M0-branes and its application for the emergence of Pauli exclusion principle in BIonic superconductors

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ABSTRACT

Recently, some authors (Cruz and Rojas, 2013 [1]) have constructed a Born–Infeld type action which may be written in terms of the Lovelock brane Lagrangians for a given dimension p. We reconsider their model in M-theory and study the process of birth and growth of nonlinear spinor and bosonic gravity during the construction of Mp-branes. Then, by application of this idea to BIonic system, we construct a BIonic superconductor in the background of nonlinear gravity. In this model, first, M0-branes link to each other and build an M5-brane and an anti-M5-brane connected by an M2-brane. M0-branes are zero dimensional objects that only scalars are attached to them. By constructing higher dimensional branes from M0-branes, gauge fields are produced. Also, if M0-branes don't link to each other completely, the symmetry of system is broken and fermions are created. The curvature produced by fermions has the opposite sign the curvature produced by gauge fields. Fermions on M5-branes and M2 plays the role of bridge between them. By passing time, M2 dissolves in M5's and nonlinear bosonic and spinor gravities are produced. By closing M5-branes towards each other, coupling of two identical fermions on two branes to each other causes that the square mass of their system becomes negative and some tachyonic states are created. For removing these tachyons, M5-branes compact, the sign of gravity between branes reverses, anti-gravity is produced which causes that branes and identical fermions get away from each other. This is the reason for the emergence of Pauli exclusion principle in Bionic system. Also, the spinor gravity vanishes and its energy builds a new M2 between M5-branes. We obtain the resistivity in this system and find that its value decreases by closing M5 branes to each other and shrinks to zero at colliding point of branes. This idea has different applications. For example, in cosmology, universes are located on M5-branes and M2-brane has the role of bridge between universes. When M5-branes become close to each other, this bridge dissolves in universes and causes that they expand. Also, when branes get away from each other, universes are contracted by compacting branes. The reason for flatness of universe in this system may be the neutralizing of curvature produced by gauge and scalar fields by the curvature produced by fermions. Using this idea in cuprates, we show that by decreasing temperature of system, branes which electrons live on it approach to each other in extra dimensions and superconductivity creates. Applying this idea in QCD, we calculate the potential between particles and anti-particles which is in good agreement with predicted potential for confined color particles. This means that one BIonic superconductor between quark and antiquark may be the main reason of confinement in QCD. Finally, in biological system, the emergence of superconductor between two neurons of two different brains via extra dimension leads to transmission of information between them and happening telepathy.

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1. Introduction

Recently, some authors [1] have proposed a Born–Infeld type theory which produces all the nonlinear terms of an effective field theory of nonlinear gravity like Lovelock theory [2]. Contrary to Lovelock theory in gravity, the number of Lovelock brane Lagrangians differs in this case and depends on the dimension of the worldvolume [2]. We extend this proposal in M-theory and show that spinor and bosonic gravities may be produced in BIonic system. The BIon consists of a brane, an anti-brane and a wormhole which connects them.

Previously, BIon has been applied in cosmology to study the evolutions of universe brane at the birth and also from inflation and deceleration to late time acceleration [3–8]. For example, in one work, a BIon can be built from joining k fundamental strings [3]. Coincidence with the creation of BIon, a universe brane and an anti-universe brane are produced which are connected with each other via a wormhole [8,6,7]. This wormhole disappears and its energy leads to growth of branes. In another paper, at the beginning, k fundamental strings convert to k pairs of M0 and anti-M0-branes. Then, M0-branes link to each other and construct a pair of six dimensional M5–anti-M5-branes. This pair disappears and an M3-brane, an anti-M3-brane in additional to one M2-brane are produced. Four dimensional universe is built on one of these M3-branes and M2 plays the role of bridge between universes. In this model, we don't have any big-bang and universe begins from a fundamental string [6]. In another research, first M0-branes wrap around a circle and N D0-branes are produced. Then, N D0-branes glue to each other and construct one D5-branes. Next, D5- brane is compacted on two circles and a D3-brane, two D1-branes and some extra energies are created. Our universe is formed on D3-brane and D1-branes dissolve in D3-brane and cause that it inflates and late time acceleration occurs [7]. And in very newest investigation, a BIonic superconductor has been introduced which can be used for describing the conductivity in nanostructures [8].

In this paper, we extend those calculations to BIonic superconductor and propose a model which considers the evolutions of entanglement between particle and the emergence of superconductivity in BIonic system. In this model, first M0-branes glue to each other and construct an M5, an anti-M5 and an M2-brane which is a bridge between them. If M0-branes link to each other completely, gauge fields are produced and if they don't join completely, the symmetry of system is broken and fermions are produced. The curvature of fermions is neutralized by the curvature of gauge fields. Fermions are placed on an M5-brane and M2 has the role of wormhole and bridge between M5's. This wormhole has the main role in producing the superconductivity. By passing time, this bridge dissolves into M5-branes, some nonlinear gravities like spinor and bosonic gravities are produced and confinement is emerged. By closing branes to each other, identical fermions which live on two branes couple to each other, the square mass of their system becomes negative and some tachyonic states are produced. For deleting these states, M5 compacts, the sign of gravity becomes reverse and the anti-gravity is created which leads to getting away of fermions from each other. For this reason, identical fermions don't become very close to each other and Pauli exclusion principle is emerged. The resistivity in this system depends on the size of M2 and M5-branes. By dissolving M2 and increasing the size of M5, the resistivity decreases and shrinks to zero at the time of collision between branes. This idea may help us to understand different phenomenological events from cosmology to QCD. For example, in cosmology, universes are located on M5-branes and interact with each other via an M2-brane as a bridge. By closing M5-branes, this bridge dissolves in universes and causes their expansion. Also, by getting away of branes from each other, universes are contracted by compacting of branes. Using this model in cuprates, temperature of system depends on the size of M2 between two M5-branes which two electrons live on it and by disappearing M2, temperature tends to critical value and superconductivity emerges. In QCD, the wormhole which connects quarks and anti-quarks in extra dimensions produces the exact form of predicted potential between confined color particles. Finally, in biological system, two neurons of two different brains can be connected by a wormhole in extra dimensions and telepathy occurs.

The outline of the paper is the following. In section 2, we consider the emergence of Pauli exclusion principle in the background of nonlinear gravity as due to the wormhole in BIonic superconductor. In section 3, we discuss how, by compacting branes, gravity changes to anti-gravity and the identical fermions get away from each other. This leads to a decrease in superconductivity of BIonic system. The last section is devoted to discussion and conclusions.

2. Emergence of a BIonic superconductor as due to nonlinear gravity in BIonic system

In this section, we argue that the relevant action of Mp-branes can be built by summing over the actions of p M0-branes. We will discuss that if M0-branes join completely, gauge fields are produced and if they are linked non-completely, fermions are created. Then, we consider the process of birth and growth of spinor gravity during the formation of Mp-branes. After that, we construct a BIonic superconductor in the back ground of Lovelock gravity in a system of M2–M5 branes. To this end, we will extend the mechanism of [9] for bosonic fields and propose a corrected model which includes both bosonic and fermionic fields. In this system, fermions live on M5-branes and interact with each other via an M2-brane. M2 has the role of bridge, dissolves in M5-branes and leads to the emergence of bosonic and spinor gravities. In the background of this gravity, the resistivity of system becomes zero and superconductivity emerges.

To begin, we will argue that the action of Dp-branes can be built by multiplying the action of D0-branes. Then, we extend this mechanism to eleven dimensional M-theory and obtain the action of Mp-branes by multiplying the action of M0-branes. The action for D1-brane can be given by [1,6,7,9–15]:

$$S = -T_{D1}\int d^2\sigma\ STr\left(-det(P_{ab}[E_{mn}E_{mi}(Q^{-1}+\delta)^{ij}E_{jn}])det(Q^i_j)\right)^{1/2} \tag{1}$$

where

$$E_{mn} = G_{mn} + B_{mn}, \qquad Q^i_j = \delta^i_j + i\lambda[X^j, X^k]E_{kj} \tag{2}$$

$\lambda = 2\pi l_s^2$, $G_{ab} = \eta_{ab} + \partial_a X^i \partial_b X^i$ and X^i are scalar fields which move in extra dimensions respect to branes. In above equation, $a, b = 0, 1, ..., p$ denote the world-volume indices of the Dp-branes, $i, j, k = p+1, ..., 9$ refer to indices of the transverse space, and m, n are the ten-dimensional spacetime indices. Also, $T_{Dp} = \frac{1}{g_s(2\pi)^p l_s^{p+1}}$ refers to the tension of Dp-brane, l_s is the string length and g_s denotes the string coupling. To calculate the action for Dp-brane, we should apply the below relations [6,7,9]: