A BIonic diode is constructed of two polygonal manifolds connected by a Chern-Simons manifold. The shape and the angle between atoms of molecules on the boundary of two polygonal manifolds are completely different. For this reason, electrons on the Chern-Simons manifold are repelled by molecules at the boundary of one manifold and absorbed by molecules on the boundary of another manifold. The attractive and repulsive forces between electrons are carried by massless photons. For example, when two non-similar trigonal manifolds join to each other, one non-symmetrical hexagonal manifold is emerged and the exchanged photons form Chern-Simons fields which live on a Chern-Simons manifold in a BIonic. While, for a hexagonal manifold, with similar trigonal manifolds, the photons exchanged between two trigonal manifolds cancel the effect of each other and BIonic energy becomes zero. Also, exchanging photons between heptagonal and pentagonal manifolds lead to the motion of electrons on the Chern-Simons manifold and formation of BIonic diode. The mass of photons depend on the shape of molecules on the boundary of manifolds and the length of BIonic in a gap between two manifolds.

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I. INTRODUCTION

A diod is constructed of one subsystem with extra electrons which are paired with extra holes in other subsystem. By applying one external force, these pairs are broken and an electrical current is produced. Until now, less discussions have been done on this subject. For example - the researches of the past few years have shown that graphene can build junctions with 3D or 2D semi-conductor materials which have rectifying characteristics and act as excellent Schottky diodes [1]. The main novelty of these systems is the tunable Schottky barrier height-a property which makes the graphene/semiconductor junction a great platform for the consideration of interface transport methods, as well as using in photo-detection [2], high-speed communications [3], solar cells [4], chemical and biological sensing [5], etc. Also, discovering an optimal Schottky interface of graphene, on other matters like Si, is challenging, as the electrical transport is corresponded on the graphene quality and the temperature. Such interfaces are of increasing research hope for integration in diverse electronic systems being thermally and chemically stable in all environments, unlike standard metal/semiconductor interfaces [6].

Previously, we have considered the process of formation of a holographic diode by joining polygonal manifolds [7]. In our model, first a big manifold with polygonal molecules is broken, two child manifolds and one Chern-Simons manifold appeared. Then, heptagonal molecules on one of child manifolds repel electrons and pentagonal molecules on another child manifold absorb them. Since, the angle between atoms in heptagonal molecules with respect to center of that is less than pentagonal molecules and parallel electrons come nearer to each other and in terms of Pauli exclusion principle, therefore are repelled. Also, parallel electrons in pentagonal molecules become more distant and some holes emerge. Consequently, electrons move from one of child manifolds with heptagonal molecules towards other child manifold with pentagonal molecules via the Chern-Simons manifold and a diode emerges. Also, we have discussed that...
this is a real diod that may be built by bringing heptagonal and pentagonal molecules among the hexagonal molecules of graphene. To construct this diode, two graphene sheets are needed which are connected through a tube. Molecules, at the junction points of one side of the tube, should have the heptagonal shapes and other molecules at the junction points of another side of the tube should have the pentagonal shapes. Heptagonal molecules repel and pentagonal molecules absorb electrons and a current between two sheets is produced. This current is very similar to the current which is produced between layers N and P in a system in solid state. This current was produced only from the side with heptagonal molecules towards the side with pentagonal molecules. Also, the current from the sheet with pentagonal molecules towards the sheet with heptagonal molecules is zero. This characteristic can also be seen in normal diod.

In this paper, we extend the consideration on holographic diodes to BIonic systems. A BIon is a system which consist of two polygonal manifolds connected by a Chern-Simons manifold. We will show that when two manifolds with two different types of polygonal molecules come close to each other, some massive photons appear. These photons join to each other and build Cherns-Simons fields. These fields lead to the motion of electrons on the Chern-Simons manifold between two manifolds and one BIonic diode emerges. The mass of these photons depend on the shape of molecules on the manifolds and the length of gap. From this point of view, our result is consistent with previous predictions for the mass of photons in [8].

The outline of the paper is as follows: In section II, we will show that by joining non-similar trigonal manifolds, a hexagonal diode emerges. In this diode, photons join to each other and form the Chern-Simons fields. In section III, we will consider the process of the formation of a BIonic diode from a manifold with heptagonal molecules, a manifold with pentagonal molecules and a Chern-Simons manifold. We will show that exchanged photons between manifold are massive and their mass depends on the length of gap between manifolds. The last section is devoted to summary and conclusion.

II. THE HEXAGONAL DIODE

In this section, we will show that a hexagonal diode can be built by joining two non-similar trigonal manifolds which exchanges photons between them form Chern-Simons fields. These fields force electrons and lead to their motion between two trigonal manifolds. Also, we will explain that if two similar trigonal manifolds join to each other, exchanged photons cancel the effect and no diode emerges.

Previously, in ref [7], for explaining graphene systems, we have used of the concept of string theory. In our model, scalar strings (X) are produced by pairing two electrons with up and down spins. Also, A denotes the photon which is exchanged between electrons and F is the photonic field strength. Now, we will extend this model to polygonal manifolds and trigonal manifolds and write the following action [7, 9, 10]:

\[ S_3 = -T_{tri} \int d^3 \sigma \sqrt{|g|} \frac{1}{\beta^2} (\sum_{n=1}^{3} (-\frac{F_{1n}}{\beta^2})^2 + 2\pi l_s^2 G(F)) \]

\[ G = (\sum_{n=1}^{3} \frac{1}{n!} (-\frac{F_{1n}}{\beta^2})) \]

\[ F = F_{\mu\nu} \quad F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu \]

where \( g_{MN} \) is the background metric, \( X^M(\sigma^a) \)'s are scalar fields which are produced by pairing electrons, \( \sigma^a \)'s are the manifold coordinates, \( a, b = 0, 1, ..., 3 \) are world-volume indices of the manifold and \( M, N = 0, 1, ..., 10 \) are eleven dimensional spacetime indices. Also, G is the nonlinear field [10] and A is the photon which exchanges between electrons. Using the above action, the Lagrangian for trigonal manifold can be written as:

\[ L = -4\pi T_{tri} \int d^3 \sigma \sqrt{1 + (2\pi l_s^2)^2 G(F) + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N} \]

where prime denotes the derivative respect to \( \sigma \). To derive the Hamiltonian, we have to obtain the canonical momentum density for photon. Since we are interesting to consider electrical solutions. Therefore we suppose that \( F_{01} \neq 0 \) and other components of \( F_{a\beta} \) are zero. So, we have

\[ \Pi = \frac{\delta L}{\delta \partial_t A^1} = -\sum_{n=1}^{3} \frac{2}{n!} (-\frac{F_{1n}}{\beta^2}) F_{01} \]

\[ \Pi = \frac{\delta L}{\delta \partial_t A^1} = -\sum_{n=1}^{3} \frac{2}{n!} (-\frac{F_{1n}}{\beta^2}) F_{01} \]
so, by replacing \( d^3\sigma = \int d\sigma d\sigma^2 \), the Hamiltonian may be built as \([9, 10]\):

\[
H = 4\pi T_{tri} \int d\sigma \sigma^2 \Pi \partial_h A^1 - L = 4\pi \int d\sigma [\sigma^2 \Pi (F_{01}) - \partial_\sigma (\sigma^2 \Pi) A_0] - L
\]  
(4)

In the second step, we use integration by parts and obtain the term proportional to \( \partial_\sigma A \). Using the constraint \((\partial_\sigma (\sigma^2 \Pi) = 0)\), we obtain \([9]\):

\[
\Pi = \frac{k}{4\pi \sigma^2},
\]  
(5)

where \( k \) is a constant. Substituting equation (5) in equation (4) and \( \int d^3\sigma = \int d\sigma d\sigma_2 d\sigma_1 \) yields the following Hamiltonian:

\[
H_1 = 4\pi T_{tri} \int d\sigma_2 d\sigma_1 \sqrt{1 + \left(2\pi l_s^2\right)^2 \sum_n \frac{n}{n!} \left(-\frac{F_1 \cdots F_{n-1}}{\beta^2}\right) + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N O_1}
\]

\( O_1 = \sqrt{1 + \frac{k^2}{\sigma^2_1}} \)  
(6)

To obtain the explicit form of wormhole-like tunnel which goes out of trigonal manifold, we need a Hamiltonian in terms of separation distance between sheets. For this reason, we redefine Lagrangian as:

\[
L = -4\pi T_{tri} \int d\sigma_2 d\sigma_1 \sqrt{1 + \left(2\pi l_s^2\right)^2 \sum_n \frac{n}{n!} \left(-\frac{F_1 \cdots F_{n-1}}{\beta^2}\right) + \sigma^2 O_1}
\]

With this new form of Lagrangian, we repeat our previous calculations. We have

\[
\Pi = \frac{\delta L}{\delta \partial_t A^1} = -\frac{\sum_n \frac{n(n-1)}{n!} \left(-\frac{F_1 \cdots F_{n-2}}{\beta^2}\right) F_{01} F_1}{\beta^2 \sqrt{1 + \left(2\pi l_s^2\right)^2 \sum_n \frac{n}{n!} \left(-\frac{F_1 \cdots F_{n-1}}{\beta^2}\right) + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N}}
\]  
(8)

So the new Hamiltonian can be constructed as:

\[
H_2 = 4\pi T_{tri} \int d\sigma \sigma^2 \Pi \partial_\sigma A^1 - L = 4\pi \int d\sigma [\sigma^2 \Pi (F_{01}) - \partial_\sigma (\sigma^2 \Pi) A_0] - L
\]  
(9)

Again, we use integration by parts to obtain the term proportional to \( \partial_\sigma A \). Imposing the constraint \((\partial_\sigma (\sigma^2 \Pi) = 0)\), we obtain:

\[
\Pi = \frac{k}{4\pi \sigma^2}
\]  
(10)

where \( k \) is a constant. Substituting equation (10) in equation (9) yields the following Hamiltonian:

\[
H_2 = 4\pi T_{tri} \int d\sigma_2 d\sigma_1 \sqrt{1 + \left(2\pi l_s^2\right)^2 \sum_n \frac{n(n-1)}{n!} \left(-\frac{F_1 \cdots F_{n-2}}{\beta^2}\right) + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N O_2}
\]

\( O_2 = O_1 \sqrt{1 + \frac{k^2}{O_1 \sigma^2_1}} \)  
(11)

And if we repeat these calculations for 3 times, we obtain

\[
H_3 = 4\pi T_{tri} \int d\sigma_3 d\sigma_2 d\sigma_1 \sqrt{1 + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N O_{tot}}
\]

\( O_{tot} = \sqrt{1 + \frac{k^2}{O_2 \sigma^2_1}} \sqrt{1 + \frac{k^2}{O_1 \sigma^2_1}} \sqrt{1 + \frac{k^2}{\sigma^2_1}} \)

\( O_2 = O_1 \sqrt{1 + \frac{k^2}{O_1 \sigma^2_1}} \)

(12)
At this stage, we will make use of some approximations and obtain the simplest form of the Hamiltonian of trigonal manifold:

\[
A \left( 1 + \frac{k^2}{\sigma^4} \right) \left( 1 + \frac{k^2}{\sigma^4} \right) \simeq A \left( 1 + \frac{k^2}{\sigma^4} \right) + A \frac{k^2}{2\sigma^4} \simeq \frac{A}{2} \left( 1 + \frac{k^2}{\sigma^4} \right) + \frac{A}{2} \left( 1 + \frac{k^2}{\sigma^4} \right)
\]

\[
2A' \left( 1 + \frac{k^2}{\sigma^4} \right) \Rightarrow O_{tot} = \frac{3}{2} \left( 1 + \frac{k^2}{\sigma^4} \right) = \frac{3}{2} O_1 \Rightarrow \frac{H_3}{4\pi T_{tri}} \int d\sigma d^2 \sqrt{1 + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N} O_{tot} = 4\pi 3T_{tri} \int d\sigma d^2 \sqrt{1 + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N} O_1 =
\]

\[
4\pi 3T_{tri} \int d\sigma d^2 \sqrt{1 + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N} \left( 1 + \frac{k^2}{\sigma^4} \right) \simeq \frac{3}{2} H_{linear}
\]

\[
H_{linear} = 4\pi 3T_{tri} \int d\sigma d^2 \sqrt{1 + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N} \left( 1 + \frac{k^2}{\sigma^4} \right)
\]

where \( A' = \frac{A}{2} \) is a constant that depends on the trigonal manifold action(\( T_{tri} \)) and other stringy constants. This equation shows that each pair of electrons on each side of trigonal manifold connected by a wormhole- like tunnel and form a linear BIon; then these Bions join to each other and construct a nonlinear trigonal BIon.

For constructing a hexagonal manifold, we should put two trigonal manifolds near each other so that direction of the motion of electrons and photons on two trigonal manifolds are reverse to each other (Fig.1.). In a symmetrical hexagonal manifold, two photons cancel the effect of each other and total energy of system becomes zero. Using expressions given in Eq. (12), we can write:

\[
\sigma_1 \rightarrow -\sigma_1 \quad \sigma_2 \rightarrow -\sigma_2 \quad \sigma_3 \rightarrow -\sigma_3
\]

\[
\int d\sigma_3 d\sigma_2 d\sigma_1 \rightarrow - \int d\sigma_3 d\sigma_2 d\sigma_1
\]

\[
A_0 \rightarrow \bar{A}_0 \quad A_1 \rightarrow \bar{A}_1
\]

\[
\Rightarrow H_3 \rightarrow -\bar{H}_3
\]

For a symmetrical hexagonal manifold, the Hamiltonians of two trigonal manifolds cancel the effect of each other and total Hamiltonian of system becomes zero. This system is completely stable and can’t interact with other systems. For a non-symmetrical hexagonal manifold, fields are completely different and two Hamiltonian cannot cancel the effect of each other. Using equations (1 and 12), we have:

\[
H_3 = 4\pi T_{tri} \int d\sigma d^2 \sqrt{1 + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N} O_{tot}
\]

\[
\neq \bar{H}_3 = 4\pi T_{tri} \int d\sigma d^2 \sqrt{1 + \eta^{ab} g_{MN} \partial_a X^M \partial_b X^N} \bar{O}_{tot}
\]

\[
\Rightarrow S = -T_{tri} \int d^3 \sigma \sqrt{\eta^{ab} g_{MN} \partial_a X^M \partial_b X^N + 2\pi l_s^2 G(F)}
\]

\[
\neq \bar{S} = -T_{tri} \int d^3 \sigma \sqrt{\eta^{ab} g_{MN} \partial_a X^M \partial_b X^N + 2\pi l_s^2 G(F)}
\]

(15)

Thus, total Hamiltonian and the action of two trigonal manifolds can be obtained as:

\[
H_{6tot} = H_3 - \bar{H}_3
\]

\[
S_{6tot} = S_3 - \bar{S}_3
\]

(16)

This equation shows that if two trigonal manifolds join to each other and form the hexagonal manifold, the Hamiltonian and also the action of hexagonal manifold is equal to the difference between the actions and Hamiltonians
of two trigonal manifolds. A non-symmetrical hexagonal manifold has an active potential and can interact with other manifolds (See Fig.2.).

At this stage, we can assert that the exchanged photons between two trigonal manifolds produce the Chern-Simons fields. To write our model in terms of concepts in supergravity, we should define G and C-fields. G-fields with four indices are constructed from two strings and C-fields with three indices are produced when three ends of G-fields are placed on one manifold and one index is located on one another manifold (Figure 3). We can define G and Cs-fields as follows:

\[ G_{IJKL} \approx F_{[IJ}F_{KL]} \]
\[ CS_{IJK} = \epsilon^{IJK}F_{IJK} \tag{17} \]

To obtain G- and Cs-fields, we will assume that two spinors with up and down spins couple to each other and exchanged photons \((X^M \rightarrow A^M\psi_1\psi_1', X^0 \rightarrow t)\). We also assume that spinors are only functions of coordinates \((\sigma, t)\). Using equation \((13, 15, 12)\), we obtain:

\[ \Pi = \frac{k}{4\pi \sigma^2} \]
\[ = \frac{\beta^2}{\sqrt{1 + \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2}} \times \]
\[ H_3 = 4\pi T \int d\sigma d\sigma d\sigma_1 \sqrt{1 + \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2} \times \]

\[ \frac{1 + \frac{1}{O_2} \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2}{\sqrt{1 + \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2}} \times \]

\[ \frac{1 + \frac{1}{O_1} \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2}{\sqrt{1 + \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2}} \times \]

\[ \frac{1 + \frac{1}{O_1} \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2}{\sqrt{1 + \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2}} \times \]

\[ H_{tot} = H_3 - \bar{H}_3 \approx \]
\[ (4\pi T \int d\sigma d\sigma d\sigma_1) \left[1 + \left(\sum_{n=1}^{3} \frac{n}{m} (-\frac{F_1 - F_{n-1}}{\beta^2})\right)^2 \right] \]
This equation shows that exchanged photons join to each other and build Chern-Simons fields. These fields make a bridge between two trigonal manifolds and produce the BIonic diode (Figure 4.). For two similar trigonal manifolds, total Hamiltonian of BIon is zero, while for two different trigonal manifolds, a BIon is emerged. This BIon is a bridge for transferring energy of one manifold to the other.

At this stage, we can obtain the mass of exchanged photons between two trigonal manifolds. The length of photon relates to the separation distance between electrons or the length of Chern-Simons manifold and the mass of photon depends on the coupling between electrons \( m^2 = \langle \psi_{1\downarrow} \psi_{1\uparrow} \psi_{2\downarrow} \psi_{2\uparrow} | \psi_{1\downarrow} \psi_{1\uparrow} \psi_{2\downarrow} \psi_{2\uparrow} \rangle \). The equation of motion for \( [A^M A_M(\psi_{1\downarrow} \psi_{1\uparrow} \psi_{2\downarrow} \psi_{2\uparrow})]' \) which is extracted from the Hamiltonian of (18) is

\[
A^M A_M(\psi_{1\downarrow} \psi_{1\uparrow} \psi_{2\downarrow} \psi_{2\uparrow}) \rightarrow m^2_{\text{photon}} l_{\text{Chern-Simons}}
\]

\[
[m^2_{\text{photon}} l_{\text{Chern-Simons}}]' = (\frac{[O_{\text{tot}}(\sigma)^2 - \bar{O}_{\text{tot}}(\sigma)^2]}{[O_{\text{tot}}(\sigma_0)^2 - \bar{O}_{\text{tot}}(\sigma_0)^2]} - 1)^{-1/2}
\]  

(20)

Solving this equation, we obtain:

\[
[m^2_{\text{photon}}] = \frac{1}{l_{\text{Chern-Simons}}} \int_\sigma d\sigma' \frac{[O_{\text{tot}}(\sigma)^2 - \bar{O}_{\text{tot}}(\sigma)^2]}{[O_{\text{tot}}(\sigma_0)^2 - \bar{O}_{\text{tot}}(\sigma_0)^2]} - 1)^{-1/2}
\]

(21)

Eq. (21) shows that photonic mass depends on the length of Chern-Simons manifold and also the length of trigonal manifolds. This result is in agreement with previous predictions in [8] that photonic mass depends on the parameters of a gap between two systems.

III. THE BIONIC DIODE

In this section, we will construct the BIonic diode by connecting a pentagonal and a heptagonal manifold by a Chern-Simons manifold. The energy and Hamiltonian of pentagonal manifold has a reverse sign in respect to the energy and the Hamiltonian of heptagonal manifold. Consequently, pentagonal manifold absorbs electrons and heptagonal molecules repel them.

A pentagonal manifold can be built of two trigonal manifolds with a common vertex (See Figure 5). Consequently, both of trigonal manifolds have a common photonic field. To avoid of calculating this photon for two times, we remove it from one of trigonal manifolds. We have:
FIG. 2: A non-symmetric hexagonal manifold is formed by joining two different trigonal manifolds. The direction of photons on two trigonal manifolds are reverse to each other, however they can’t cancel the effect of each other.

FIG. 3: GG-fields and Cs-fields are formed by joining exchanged photons.

\[
\begin{align*}
S_5^{\text{tot}} &= S_3 - \tilde{S}_2 \\
H_5^{\text{tot}} &= H_3 - H_2
\end{align*}
\]

Following the mechanism in previous section, we obtain following actions:

\[
S_3 = -T_{tri} \int d^3\sigma \sqrt{\eta^{ab} g_{MN} \partial_a X^M \partial_b X^N + 2\pi l_s^2 \left( \sum_{n=1}^{3} \frac{1}{n!} \left( - \frac{F_1 F_n}{\beta^2} \right) \right)}
\]

FIG. 4: A hexagonal diode consisted of two trigonal manifolds are connected by a Chern-Simons manifold.
\[ S_2 = -T_{tri} \int d^3\sigma \sqrt{\eta^{ab}g_{MN}\partial_a X^M \partial_b X^N + 2\pi l_s^2 \left( \sum_{n=1}^{2} \frac{1}{n!} (-\frac{F_n}{\beta^2}) \right)} \]

(23)

and following Hamiltonians:

\[
H_3 = 4\pi T_{tri} \int d\sigma_3 d\sigma_2 d\sigma_1 \sqrt{1 + \eta^{ab}g_{MN}\partial_a X^M \partial_b X^N O_{tot}^3} \\
\neq H_2 = 4\pi T_{tri} \int d\sigma_3 d\sigma_2 d\sigma_1 \sqrt{1 + \eta^{ab}g_{MN}\partial_a X^M \partial_b X^N O_{tot}^2} \\
O_{tot}^3 = \sqrt{1 + \frac{k_2^2}{O_2 \sigma_3^2}} \sqrt{1 + \frac{k_2^2}{O_1 \sigma_2^2}} \sqrt{1 + \frac{k_2^2}{O_1 \sigma_1^2}} \\
\bar{O}_{tot}^2 = \bar{O}_1 \sqrt{1 + \frac{k_2^2}{O_2 \sigma_2^2}}
\]

(24)

After doing some algebra on the above Hamiltonians and using the mechanism in (19), we obtain:

\[
H_{tot}^5 = H_3 - H_2 \approx -\left(4\pi T_{tri}\right) \left[1 + \left(\frac{2\pi l_s^2}{\beta^2}\right)\left(\bar{G}_{IJKL}G^{IJKL} - G_{IJKL}G^{IJKL}\right)\right] \\
+ \left(\frac{2\pi l_s^2}{\beta^2}\right)^2 \left(\psi_{1,1}\psi_{1,\uparrow}\psi_{2,\downarrow}\psi_{2,\uparrow}\uparrow'\right) CsG_{IJKL}G^{IJKL} - \bar{C}s\bar{G}_{IJKL}G^{IJKL}\right] \\
- \left(\frac{2\pi l_s^2}{\beta^2}\right)^3 \left[\bar{G}_{IJKLMN}G^{IJKLMN}\right] \\
- \left(\frac{2\pi l_s^2}{\beta^2}\right)^3 \left(\psi_{1,1}\psi_{1,\uparrow}\psi_{2,\downarrow}\psi_{2,\uparrow}\uparrow'\right) \left[Cs\bar{G}_{IJKLMN}G^{IJKLMN}\right] + \ldots ....
\]

(25)

This equation shows that similar to the hexagonal manifold, the exchanged photons between trigonal manifolds in pentagonal manifold form Chern-Simons fields, however the pentagonal manifold has less Chern-Simons and GG-fields. This is because that the pentagonal manifold has less sides in respect to hexagonal manifold and consequently, it’s exchanged photons are less.

FIG. 5: A pentagonal manifold is formed by joining two trigonal manifolds with a common vertex.

Also, using the Hamiltonians in equation (24) and assuming all coordinates are the same (\( \sigma_1 = \sigma_2 = \sigma_3 \)), we obtain:

\[ E_{tot}^5 = H_3 - H_2 \approx 4k\pi T_{tri}\left[\frac{1}{\sigma^3} - \frac{1}{\sigma^3}\right] \]

\[ F = -\frac{\partial E}{\partial \sigma} = 4k\pi T_{tri}\left[\frac{1}{\sigma^6} - \frac{1}{\sigma^4}\right] \ll 0 \]

(26)
This equation shows that the force which is applied by a pentagonal manifold to an electron is attractive. Thus this manifold attracts the electrons. In fact, a pentagonal manifold should be connected by another manifold and obtain the needed electrons. In next step, we want to consider the behaviour of heptagonal manifolds. A pentagonal manifold is formed by joining three trigonal manifolds which have two common vertexes. These two trigonal manifolds build a system with four vertexes and four fields (See figure 6 and figure 7). Thus, we can write:

\[ S_{7}^{\text{tot}} = S_{3} - \tilde{S}_{3-3} \]
\[ H_{7}^{\text{tot}} = H_{3} - \tilde{H}_{3-3} \]

(27)

Using the method in previous section, we obtain following actions

\[ S_{7} = -T_{\text{tri}} \int d^{3} \sigma \sqrt{1 + \eta^{ab} g_{MN} \partial_{a} X^{M} \partial_{b} X^{N} O_{\text{tot}}^3 + 2 \pi l_{s}^{2} \sum_{n=1}^{3} \left( \frac{1}{n!} \left( \frac{F_{1} - F_{n}}{\beta^2} \right) \right)} \]
\[ \tilde{S}_{3-3} = -T_{\text{tri}} \int d^{3} \sigma \sqrt{1 + \eta^{ab} g_{MN} \partial_{a} X^{M} \partial_{b} X^{N} \tilde{O}_{\text{tot}}^{3-3} + 2 \pi l_{s}^{2} \sum_{n=1}^{4} \left( \frac{1}{n!} \left( \frac{F_{1} - F_{n}}{\beta^2} \right) \right)} \]

(28)

and following Hamiltonians:

\[ H_{3} = 4 \pi T_{\text{tri}} \int d\sigma_{3} d\sigma_{2} d\sigma_{1} \sqrt{1 + \eta^{ab} g_{MN} \partial_{a} X^{M} \partial_{b} X^{N} O_{\text{tot}}^3} \]
\[ \neq \tilde{H}_{3-3} = 4 \pi T_{\text{tri}} \int d\tilde{\sigma}_{3} d\tilde{\sigma}_{2} d\tilde{\sigma}_{1} \sqrt{1 + \eta^{ab} g_{MN} \partial_{a} X^{M} \partial_{b} X^{N} \tilde{O}_{\text{tot}}^{3-3}} \]

(29)

Using the Taylor series in the above Hamiltonians and applying the method in [19] yields:

\[ H_{7}^{\text{tot}} = H_{3} - \tilde{H}_{3-3} \cong \]
\[ -(4 \pi T_{\text{tri}})[1 + \left( \frac{2 \pi l_{s}^{2}}{\beta^2} \right)] \tilde{G}_{IJJKL} \tilde{G}^{IJJKL} - \tilde{G}_{IJJKL} G^{IJJKL} \]
\[ + \left( \frac{2 \pi l_{s}^{2}}{\beta^2} \right)^{2} (\psi_{1,4} \psi_{1,4}^{\dagger} \psi_{2,4}^{\dagger} \psi_{2,4} + \dagger') [C s \tilde{G}_{IJJKL} \tilde{G}^{IJJKL} - C s G_{IJJKL} G^{IJJKL} \]
\[ - \left( \frac{2 \pi l_{s}^{2}}{\beta^2} \right)^{3} \tilde{G}_{IJJKL MN} \tilde{G}^{IJJKL MN} - \tilde{G}_{IJJKL MN} G^{IJJKL MN} \]
\[ - \left( \frac{2 \pi l_{s}^{2}}{\beta^2} \right)^{3} (\psi_{1,4} \psi_{1,4}^{\dagger} \psi_{2,4}^{\dagger} \psi_{2,4} + \dagger') [C s \tilde{G}_{IJJKL MN} \tilde{G}^{IJJKL MN} - C s G_{IJJKL MN} G^{IJJKL MN} \]
\[ - \left( \frac{2 \pi l_{s}^{2}}{\beta^2} \right)^{4} \tilde{G}_{IJJKL MN YZ} G^{IJJKL MN YZ} \]
\[ - \left( \frac{2 \pi l_{s}^{2}}{\beta^2} \right)^{4} (\psi_{1,4} \psi_{1,4}^{\dagger} \psi_{2,4}^{\dagger} \psi_{2,4} + \dagger') [C s \tilde{G}_{IJJKL MN YZ} G^{IJJKL MN YZ} + \ldots \ldots \ldots] \]

(30)

This equation indicates that like the hexagonal and pentagonal manifold, the exchanged photons between trigonal manifolds in hexagonal manifold form Chern-Simons fields, however the hexagonal manifold has more Chern-Simons and GG-fields. This is because that the heptagonal manifold has more sides in respect to hexagonal manifold and consequently, it’s exchanged photons are more.
Similar to pentagonal manifold, using the Hamiltonians in equation (29) and assuming all coordinates are the same \((\sigma_1 = \sigma_2 = \sigma_3)\), we obtain:

\[
E^{\text{tot}}_7 = H_3 - \tilde{H}_{3-3} \approx 4k\pi T_{\text{tri}}\left\{\frac{1}{\sigma^3} - \frac{1}{\sigma^9}\right\}
\]

\[
F = \frac{\partial E}{\partial \sigma} = 4k\pi T_{\text{tri}}\left\{\frac{1}{\sigma^6} - \frac{1}{\sigma^{10}}\right\} \gg 0
\]

This equation indicates that the force which is applied by a heptagonal manifold to an electron is repulsive. Thus this manifold repels the electrons. In fact, a heptagonal manifold should be connected by a pentagonal manifold and gives the extra electrons to it.

\[
\text{FIG. 6: Two trigonal manifolds with two common vertexes.}
\]

\[
\text{FIG. 7: A heptagonal manifold is formed by joining three trigonal manifolds which two of them have two common vertexes.}
\]

A Blonic diode can be constructed from a pentagonal manifold which is connected to heptagonal manifold via a Chern-Simons fields (See figure 8). Using the Hamiltonians in (29) and (30), we obtain:

\[
H^{\text{Diode}}_{\text{tot}} = H^{\text{tot}}_5 + H^{\text{tot}}_7 \approx
-(4\pi T_{\text{tri}})[-(\frac{2\pi t^2}{\beta^2})^3\tilde{G}_{IJJKLMN}G^{IJJKLMN}]
-(\frac{2\pi t^2}{\beta^2})^3(\psi_1,\downarrow\psi_1,\downarrow\psi_2,\downarrow\psi_2,\uparrow)'[CsG_{IJJKLMNYZ}G^{IJJKLMNYZ}]
-(\frac{2\pi t^2}{\beta^2})^4(\psi_1,\downarrow\psi_1,\downarrow\psi_2,\downarrow\psi_2,\uparrow)'[\tilde{G}_{IJJKLMNYZ}G^{IJJKLMNYZ}] + \ldots\ldots
\]

This equation shows that the Hamiltonian of the Blonic diode includes terms with 6 and 8 indices. This means that the rank of Cs-GG terms in a pentagonal-heptagonal diode is more than the rank of Cs-GG terms in a hexagonal.
diode. In fact, in pentagonal-heptagonal diode more photonic fields are exchanged and stability of system is more than the hexagonal diode.

Using equations (21, 24, 29) we can obtain the photonic mass in a BIonic diode:

\[
\left[ m^2_{\text{photon}} \right] = \frac{1}{l_{\text{Chern-Simons}}} \int_{\sigma}^{\infty} d\sigma' \left( \frac{|O_{\text{Diode}}(\sigma)^2 - \bar{O}_{\text{Diode}}(\sigma)^2|}{|O_{\text{Diode}}(\sigma_0)^2 - \bar{O}_{\text{Diode}}(\sigma_0)^2|} \right)^{-1/2}
\]

(33)

where

\[ O_{\text{Diode}} = 2O_{\text{tot}}^3 - O_{\text{tot}}^3 - O_{\text{tot}}^2 \]

(34)

In a pentagonal-heptagonal BIonic diode, the photonic mass depends not only on the separation distance between manifolds but also on the shape and topology of trigonal manifolds which construct manifolds. It is clear that for a small gap between manifolds, coupling of photons to electrons on the Chern-Simons manifold increases and they become massive.

**FIG. 8:** A BIonic diode can be constructed from a pentagonal manifold which is connected to heptagonal manifold via a Chern-Simons manifold.

**IV. SUMMARY**

In this paper, we have considered the formation and the evolutions of BIonic diodes on the polygonal manifolds. For example, we have shown that a hexagonal BIonic diode can be constructed by two non-similar trigonal manifolds. Photons which are exchanged between trigonal manifolds, form Chern-Simons fields which live on a Chern-Simons manifold. The hexagonal BIons interact with each other via connecting two Chern-Simons manifolds. For a hexagonal manifold with similar trigonal manifolds, exchanged photons cancel the effect of each other and the energy and also the length of Chern-Simons manifold becomes zero. These manifolds are stable and cannot interact with each other. If the symmetry of hexagonal manifolds is broken, another polygonal manifolds like heptagonal and pentagonal manifolds are formed. Photons that are exchanged between these manifolds form two Chern-Simons fields which live on two Chern-Simons manifolds. These manifolds connect to each other and construct a BIonic diode. Photons that move via this manifold, lead to the motion of electrons from heptagonal side to pentagonal side. These photons are massive and their mass depends of the angles between atoms and length of gap between two manifolds.

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