The Modelling of Cell Membrane Electrodynamics

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Abstract — **Main electrical processes in cells are defined by membranes. The membrane maintains a biochemical environment inside the cell that differs from the outside one, keeping the electrical potential negative inside the cell and organizing the selective transport across the surface. In the paper, it is attempted to explain the cell membrane electrodynamics using modelling experiments with magnetic dipoles. It is shown that the membrane has a definite symmetry or handenness. In addition, a characteristic mechanism of the excited state physics is given. The modelling experiments have also shown that a membrane with different symmetry can exist. Since the electrical processes in these cases are different, such cells could be dangerous to organisms. The recent knowledge of physical processes in a carbon sheet just of one atom thick and its biophysical aspects are discussed.**

I. INTRODUCTION

In recent years, researchers very actively investigate one-atom-thick crystalline and plane (2D) systems. An example on the crystalline element is the buckyballs also known as C_{60} that had been discovered in 1985 [1].There is not only C_{60}, but a whole family of related molecules. Carbon atoms are connected by electrical (quantum mechanical) forces and form a periodical structure.

Examples of plane 2D systems are graphene, graphane and graphyne. Since the physical processes in such systems are at starting positions, there are no review monographs, but all interesting effect one can find by clicking in the internet. The main characteristics of such 2D systems are the one-atom-thick layer and the periodic character of structure. Graphene and graphyne are electrical conductors. The conductivity is realized by electrons. There are some new specific effects, which allow electrons to be massless and transferred along the film surface with very a high speed. Graphene has a hexagonal structure, but graphyne is a combination of hexagons and tetrahedrons [2]. In comparison with graphene and graphyne, graphane is an electrical insulator because its electron bonds are saturated with some atom (usually H) absorbed on the film surface. There are no free electrons and no electrical conductivity. Another interesting effect is that on the film surface there locally exists a region strained in a particular way that influences the electron transfer character. The electrons start rotating around the strained zone, and physically it is like existence of a strong local magnetic field [3].

II. RESULTS OF MODELLING EXPERIMENTS

Due to some analogy between electric and magnetic characteristics in modelling experiments, small magnetic balls were used. In this case, main forces between balls are dipole-dipole interactions. Magnetic balls of 5 mm in diameter and maximum induction of 100 mT are used. We will start with a model of C_{60} molecule known as the buckyballs. There are 20 hexagonal and 12 pentagonal elements, which make approximately a round surface (fig. 1).

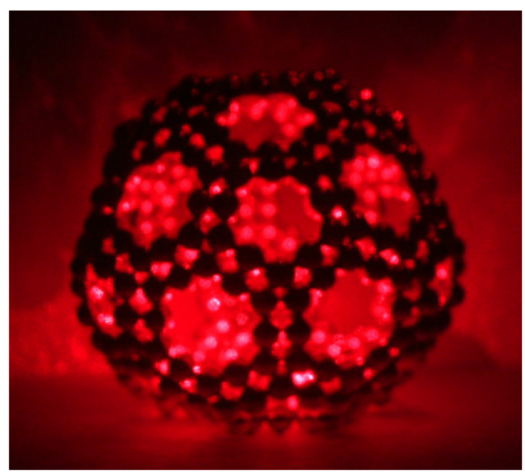

Fig. 1 The model of magnetic buckyballs with definite symmetry.

If we try to complete the plane elements, the hexagon is still plane, but pentagons can make either a convex or a concave structure. In each element in the central part, there is a channel that could be modelled for outside–inside communications (fig.2).

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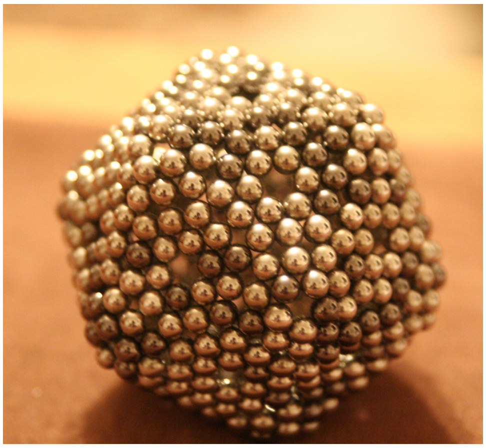

Fig. 2 The buckyballs membrane model with all 12 pentagons in the convex state.

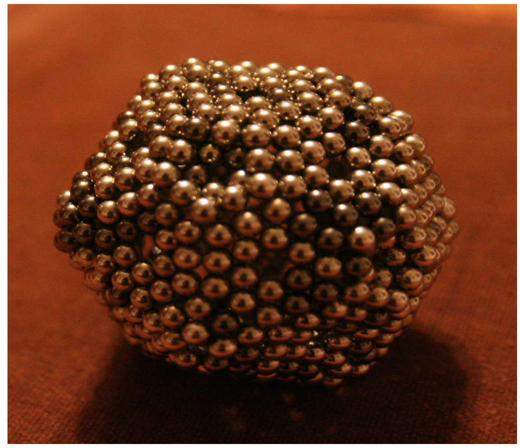

Fig. 3 The membrane model when three pentagons are in the concave state.

If there appears some local or global membrane straining actions, the pressure increases inside the cell and an ion current is generated from inside to outside. Another possibility is the current generator by regular pentagon changes from convex to concave configuration. In fig. 3, three pentagons are shown in the concave state.

The current pulse generates a magnetic field around the flow. Such field tries to conserve the current value and initiate the known "overshoot" effect. Due to the small geometry of the pump channel, which is also an electrical current dimension, there could appear resonant effects [4]. In fact, the electrical current retains the potential inside the cell and goes to the initial negative value with a small returning "overshoot". There are two important things. First, all elements in figs.2, 3 are with the same symmetry. Second, it is possible to decrease the geometry of the elements by going to polyhedrons. It means to decrease the size of the balls and increase the number of the elements. Therefore, we can have also a molecular dimension. The communication across the membrane is realized by ions or by dipole particles. Taking into account many specific effects of electrons in such one-atom-thin film, an important role of electrons for communications along the membrane surface as well as for global communication between cells in the organism as a whole is acknowledged.

The model (figs. 2, 3) has a definite symmetry, let us say left-handed. It is possible to use the same elements to manage buckyballs with a right-handed symmetry. There will be no difference visually, but the changes can initiate differences in communication and interaction processes. By splitting the process, such abnormal cell will generate cells with the same symmetry. Such membranes and cells could be dangerous to organisms. In the modeling experiments, we used the magnetic dipole, but there is analogy with the electrical one. In the membrane, we have a normal electric field. We can suppose that there is also a magnetic field around the electric field.

How to destroy the cell membrane? In the modelling experiments, it is realized by taking out separate elements step by step. Another way is to increase the pressure inside the cell that will initiate the cell decay in separate elements. In modelling experiments, it is possible to make a two-layer model as well as an onion type one.

III. Conclusion

The carbon film investigation is just at starting position, and every day brings some new surprising physical results. We focus on some interesting processes, which could occur in biomembranes. The structure of the carbon sheet as well as C_{60} is made by atoms. In biomembranes, we have molecular complexes. In the modelling experiments, we have used macro dipoles. It seems that there is a physical analogy and no influence of the dimension scale. Modelling experiments with magnetic dipoles allow to extend the results also to systems with electrical dipoles. There are enormous experimental and theoretical data in cells membranes science, and the discussed results could only serve as ideas that would stimulate future investigations.

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