Romanian Reports in Physics, Vol. 60, No. 3, P. 885–898, 2008

Dedicated to Prof. Ioan-Iovitz Popescu's 75th Anniversary

PHYSICAL BASIS OF BIOPHOTON EMISSION AND INTERCELLULAR COMMUNICATION

E. LOZNEANU, M. SANDULOVICIU

Complex system laboratory, Faculty of Physics, "Al. I. Cuza" University, Iași, Romania

(Received March 11, 2008)

Abstract. Based on a new scenario of self-organization that explains the mechanism by which cell-like space charge configurations, dubbed plasma blobs, emerged in plasma survive by emission of photons a new conceptual model of the emission of biophotons by living system is proposed. Phenomena as coherent emission and other features specific to biophoton emission also revealed by these plasma blobs offer the possibility to identify the physical background of phenomena hitherto not conclusively understood in the science of biophotonics.

Key words: self-organization, collective quantum effects, plasma blob, biological coherence, change of information.

1. INTRODUCTION

Living cells emit in the surroundings electromagnetic energy in the form of photons. Discovered in 1920 by the Russian embriologist Alexander Gurwitsch the magnitude of this photon emission is weaker than the well-known normal bioluminescence but stronger than the black body radiation. After its discovery, Gurwitsch demonstrated that one plant separated by quartz barrier from another one (for impeding chemicals messengers) stimulates the growth of the last one. For explaining this astonishing phenomenon, Gurwitsch suggested emission and reception of photons. Ignored by the scientific community, this phenomenon was "rediscovered" after the end of the second world war by Western, Australian and Japanese scientists. The common basis by which these scientists tried to explain this phenomenon is the hypothesis that the photon emission is related to rare oxidation processes and radical reactions.

Beginning from 1972, Fritz-Albert Popp [1] and his research group in Marburg, Germany, have shown that the spectrum of the emitted photons has range of wavelengths from 200 to 800 nm and a magnitude from a few up several hundred photons per second per square centimeters of surface aria of the emitting living matter. By using special techniques, that include single photon counters, it was established that: (i) the radiation originates from an almost perfectly coherent photon field; (ii) essential sources of the radiation are DNA and corresponding resonators in the cell; (iii) the mechanism involves photon storage in cavities and informational channels turned by Casimir forces; (iv) there is close connection to delayed luminescence which corresponds to excited states of the coherent photon field; (v) the occupation of the photons in the phase space is the same for all wavelengths and extends up to the so called hot radiation of the body; (vii) the radiation is the proper regulator and information carrier of life.

Hitherto the emission of biophotons was physically modelled starting from the concept of quantum coherence, a mechanism that allows to consider the living cell as an open dissipative structure whose metabolic activity holds them far away from thermal equilibrium. The way by which this was theoretically modeled involves a nonlinear coupling between a set of harmonic oscillators associated with bioconstituents of a given kind and the surrounding heat bath. In this model the “self-organizing” ability of such structures is related to a single oscillation mode namely that which is the most strongly excited. The frequency of this so-called supra-thermal excitation is that of the lowest frequency of the oscillators [2].

In spite of the great progress in theoretical modeling of the mechanism by which living matter emits light, the elucidation of the genuine physical basis remained open and therefore one of the most fascinating interdisciplinary approaches of the fundamental science. This is because there exists a very large lot of possible application and rapid integration in nano-technology, optical engineering, food science, environmental protection, living technology, artificial life, complementary and alternative medicine but also others ones.

In this paper we tentatively explain the emission of biophotons starting from the already expressed hypothesis that the eukaryotic nucleus of the contemporary cell is the successor of an ancestor gaseous cell emerged by self-organization under early Earth conditions when water and organic matter was not present [3]. This hypothesis was recently substantiated demonstrating that plasmas naturally self-organize in stable interacting helical structures that exhibit features normally attributed to organic living matter [4]. For arguing our hypothesis we will explain how in argon plasma a coherent, stable and luminous gaseous body dubbed plasma blob [5] emerges by self-organization. Its internal structure and behavior satisfy, in a great extend, the criteria to be considered an autopoietic machine. Such a machine, defined to characterize the nature of living systems performs “a network of processes of production (transformation and destruction) of components which: (i) through their interactions continuously regenerate and realize the network of processes that produced them; and (ii) constitute it (the machine) as a concrete unity in space in which they (the components) exist by specifying the topological domain of its realization as such a network” [6].

2. PLASMA BLOBS AS AUTOPOIETIC MACHINE

A device suitable to identify all phenomena involved in the emergence of a plasma blob is a diode whose cathode acts as a plasma source from which the plasma reaches the anode by diffusion. The diode is filled with argon at a pressure in the order of (10^{-1}–10^{-2}) Pascal. By gradually increasing and decreasing the voltage delivered from an external dc power supply (PS), the static $I(V)$–characteristic shown in Fig. 1 is obtained.

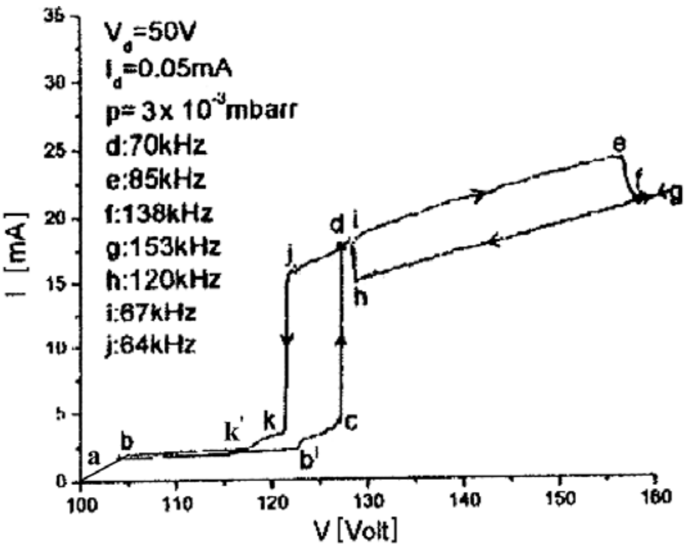

Fig. 1 – Static $I(V)$ characteristic obtained from a plasma diode. Gas argon, V_d voltage I_d current of the plasma source. Most of the voltage V is supported by the plasma column.

This characteristic reveals the presence of different nonlinear phenomena (instabilities) that determine a very quick transition of the gaseous conductor from a conduction state to another one. Thus, for small values of the voltage of the PS and implicitly of the anode, the gaseous conductor behaves as a simple resistor (branch **a**-**b**). Increasing the voltage of PS, a net negative space charge appears in front of the anode by accumulation of those electrons that have lost their kinetic energy after atom excitations. Acting as a barrier for the current, these electrons change the slop of the static $I(V)$-characteristic (branch **b-b′**). By additionally increasing of the PS voltage, the potential of the anode reaches a value for which I changes spontaneously its slope (branch **b′-c**). This change of the slop signifies the appearance of ionization processes [7]. Owing to the fact that the electrons that produce and those resulting after ionizations are quickly collected by the anode, the positive ions, whose mass is much greater than that of electrons, form a net positive space charge in front of the anode. In this way, a bipotential structure is assembling whose shape depends on the structure of the electric field created by the anode. When the anode surface is small, the bipotential structure has the shape of a nearly spherical double layer (NSDL). A critical state of the plasma diode is attained when the anode potential reaches the value marked **c** in Fig. 1 for which I increases abruptly for constant voltage of PS. The single possibility to explain this nonlinear phenomenon is to consider that an internal acting cause spontaneously changes the internal resistance of the gaseous conductor. This means that for constant value of the PS voltage the plasma is able to create itself, *i.e.*, by self-organization, a new source of free electrons and positive ions. Because new charged particles could be created in the plasma diode only by atom ionization, it results that a phenomenon by which the ionization rate increases very quickly takes place inside the plasma diode. Such a phenomenon, in detail already described [7], is a self-enhancement of the production of positive ions related to acceleration of successive groups of electrons originating from a population characterized by a quasi-maxwellian energy distribution function. Taking into account that the ionization rate depends, besides the kinetic energy of the accelerated electrons, also on their initial thermal energy, by gradually increasing the PS voltage, those electrons whose thermal energy is maximal firstly produce atom ionization and implicitly excitations. Since the anode quickly collects the electrons that produced and those resulted after ionizations, the potential drop on the NSDL depends on the voltage of the anode. So, successive new groups of electrons whose thermal energy corresponds to the descendent branch of their thermal energy distribution function produce new ionizations and implicitly excitations when the voltage of the anode is gradually increased. In this way the potential drop sustained by the NSDL increases reaching a critical state for which the electrostatic forces, that act as correlation forces between the adjacent two opposite space charges, become dominant with respect to the forces by which the electric field created by the anode acts on them. In this moment, the adjacent net space charges quickly approach each other and simultaneously the potential drop sustained by the NSDL structure increases so that a new group of electrons whose thermal energy is smaller but their number greater produce new ionization after acceleration in this new potential drop. Since the anode collects the electrons that produced and those resulted after ionizations, the potential drop supported by the NSDL again increases. Consequently a new group of electrons whose thermal energy is smaller but their number greater produce additional ionizations, and so on. In this way it works an internal positive feedback mechanism by which I abruptly increases. In Fig. 1 this nonlinear phenomenon starts for a voltage of the anode marked by the point **c**. Evidently, because of the random motion of the electrons, only a part of them, namely those whose momentum is so oriented that their thermal energy is added to the kinetic energy obtained after acceleration in the NSDL structure, increases the ionization rate.

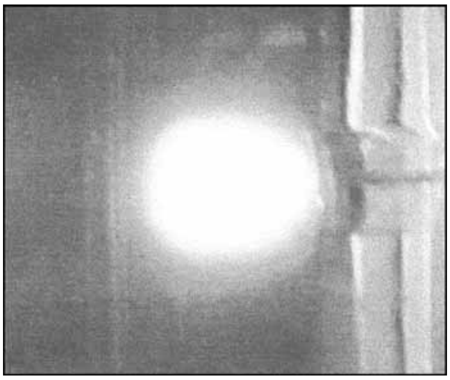

Fig. 2 – Photography of the plasma blob.

During this abrupt increase of I (branch **c-d**), the electric field intensity created by the positive ions located at the positive side of the NSDL increases so that the region where the electrons are accumulated after atom excitations is quickly shifted away from the anode. Since the positive net space charge at the positive side of the NSDL follows the net negative one the NSDL expands. The expansion of the NSDL is stopped when the lost of positive ions and electrons after recombination, diffusion and so on is compensated by new positive ions and electrons accumulated at the two sides of the NSDL. In this final phase of evolution the NSDL performs labor by accelerating electrons extracted from the surrounding plasma at energies for which atom ionizations and implicitly excitations take place. Since the excited and ionized atoms quickly return to the ground state, the survival of the plasma blob involves emission of photons. So, a plasma blob attached to the anode emerges by self-organization (see Fig. 2). As proved by probe measurements, the potential at the positive side of the NSDL at the border of the plasma blob surpasses the potential of the anode [7]. This is a very important experimental result because it proves that the evolution of the NSDL comprises two distinct phases. The first phase corresponds to the time span in which the potential drop on the NSDL increases because the anode collects the electrons that have produced and those resulted after ionizations at its positive side. During this phase, the afore-described self-enhancement process of the production of positive ions develops. During this process, thermal energy extracted from the plasma is directly converted into energy of the electric field of the NSDL by work done by the **dc** power supply. The second phase reveals that the NSDL has "learned" the mechanism by which it evolved in the first phase so that it continues this evolution in absence of work done by the dc PS, *i.e.*, by self-organization. During the first phase of evolution the potential at the positive side of the NSDL just reaches the potential of the anode. During the second phase of evolution, this potential becomes greater than the potential of the anode. The single possibility to explain this phenomenon is to take into account that during ionizations also a local heating process takes place [7]. So, after thermal diffusion, the electrons leave the positive side of the NSDL and consequently the potential at the positive side of the NSDL is maintained greater than the potential of the anode. Under this circumstance, for reaching the anode, the electrons have to penetrate a decelerating electric field. This means that only a relative small part of electrons that produce and that result after ionizations at the positive side of the NSDL really sustain the ionization rate required for ensuring the existence of the plasma blob. The mechanism by which this takes place involves transport of thermal energy from the plasma into the "warmer" plasma located at the positive side of the NSDL. This is evidently a mechanism that defies the second law of thermodynamics [3].

Accelerating electrons extracted from the plasma at energies for which they ionize and implicitly excite atoms, the NSDL performs labor. Since the ionized and excited atoms quickly return to the ground state, electromagnetic energy (photon) is emitted in the surroundings. So, by a mechanism that exploits collective effects of quantum processes, the plasma blob "lives" by permanently consuming matter and thermal energy extracted from the plasma. In this state the blob reveals certain robustness surviving, when the **dc** power supply is disconnected, for a duration that substantially surpasses the time span in which it emerged by self-organization. This robustness is also emphasized decreasing the PS voltage below the value for which the plasma blob has emerged. In Fig. 1 this robustness is emphasized by the presence of the branch **d-j** on which the plasma blob continues to exist. For existing under such conditions, the ionization rate at the positive side of the NSDL must be maintained constant at the value for which the plasma blob emerged. Since this ionization is sustained both by the electric field proper to the NSDL and that of the anode, the decrease of the potential diminishes also the ionization rate. This means that the existence of the plasma blob is possible only if the plasma contains a number of electrons whose thermal energy corresponds to the part of the descendent branch of their thermal energy distribution function placed below the top of this distribution function [7]. This means that in the plasma there exists a "reserve" of electrons whose thermal energy added to the energy obtained after acceleration in the NSDL ensures the critical ionization rate required for maintaining the existence of the plasma blob also when the potential of the anode is decreased. By ionizations and implicitly excitations collective effects of quantum processes are exploited for ensuring the ionization rates required to compensate the lost of electrons and positive ions at the two sides of the NSDL by recombination diffusion and so on. The evolution of the NSDL takes place because it is produced so quickly that the ionized atoms have not the time to return by recombination to the ground state. So, by a statistical equilibrium that involves continuous emission of photons, it is maintained the electric "skeleton" of the NSDL in a gaseous medium. This skeleton is able to support a proper potential drop that equals/surpass the ionization potential of the gas, by permanently extracting thermal energy from the plasma.

In the vocabulary of thermodynamics, this means that for maintaining its internal order the plasma blob produces negative entropy converting thermal energy into ordered electric field energy but simultaneously electromagnetic energy is emitted in the surroundings. After dissipation, this energy creates an equivalent amount of positive entropy in the surroundings.

Emerged through a "bifurcation" like instability (branch **c-d**) that acts as a memory mark, the plasma blob emphasize the quality of an intelligent complexity endowed with a flash memory [7]. The mechanism by which this flash memory works is physically based on labor performed by the NSDL by continuous extraction of thermal energy from the plasma. This is experimentally proved by permanent emission of photons. Endowed with an algorithm of instructions "learned" during its emergence by self-organization, the NSDL works as a "machine" that, by a mechanism exploiting collective effects of quantum processes, directly converts thermal energy into electric field energy [3, 7]. Applying the general autopoietic criteria to the plasma blob following questions warrant answers: does the matter self-assemble into a system boundary structure? is there an exchange of matter and energy across that boundary?; does the enclosure exhibit an electrical gradient?; is the gradient sufficient to transport and transform matter throughout the system boundary?; are all components produced within the system?; are all components replaced by such transformation within the system? Since all these questions could be positively answered it results that from the point of view of the autopoietic criteria the plasma blob reveals qualities similar to those of a "living" system. However, observed in plasma devices where the plasma is locally driven away from thermal equilibrium by using an external imposed electric field, the plasma blobs missed one of the most important quality of life namely to live after its "birth" also in absence of an external acting driving force.

3. DYNAMICAL BEHAVIOR OF THE PLASMA BLOB

Endowed with a flash memory, the plasma blob attributes to the diode the quality to perform useful work. Thus, connecting the plasma diode to a circuit able to oscillate naturally, oscillations are stimulated and entertained [8]. They appear when the voltage of PS is fixed at the value for which, because of the emergence of the plasma blob, the internal resistance of the plasma quickly decreases. Consequently, the current I collected by the anode increases and simultaneously the potential drop on the plasma diode decreases. When the resistance of the load resistor surpasses a certain value, the potential supported by the plasma diode diminishes at the critical value for which the plasma blob disrupts. In this moment the electric energy "sequestered" in the plasma blob after direct conversion of thermal energy extracted from the plasma is quickly injected into the circuit. Consequently, oscillations appear. Their amplitude grows up to the moment when the amount of energy injected into the circuit after disruption is compensated by the amount of energy dissipated during one period of the oscillations. In this way the plasma diode works as an S-shaped negative differential resistance (S-NDR). During the oscillations, the current I runs through all branches of the hysteretic cycle marked **c-d-j-k-k′-b′-c** in Fig. 1. This cycle comprises the branch **c-d** in which thermal energy extracted from the plasma is directly converted into a part of the energy of the electric field located in the NSDL (namely that corresponding to the potential drop between the positive side of the NSDL and the anode) and the branch **d-j** on which the plasma ball survives performing the operations "learned" during its emergence by self-organization. Both phases involve emission of photons so that this work is performed by exploitation of collective effects of quantum processes. When the potential of the anode reaches the value marked by **j** the plasma blob disrupts. Consequently the thermal energy extracted from the plasma during its emergence that remains sequestered in the plasma blob during its survival when the branch **d-j** is running through is injected into the oscillatory circuit. Ceasing to act as internal source of free electrical charges, the internal resistance of the plasma diode increases quickly so that the potential of the anode grows again at the voltage for which new plasma blob emerges. Between the disruption and the emergence of a new plasma blob, the current I runs on the branch **k′-b′-c**. For working as a S-NDR the thermal energy extracted from the plasma during one period of the oscillation have to be replaced by work done by the plasma source. Since the proper circuit of the plasma source is not included in the circuit connected between the anode and the plasma source the static $I(V)$–characteristic reveals the presence of an additional internal source of energy by the presence of an S-NDR. The genuine origin of this energy, up yet not conclusively explained, is the thermal energy extracted from the plasma by a mechanism "learned" by the NSDL during self-organization. Owing to the fact that the plasma blob emerges and survives by a mechanism that involves emission of electromagnetic energy (photons) in an amount that compensates the amount of thermal energy extracted from the plasma, it results that during the oscillations the amount of thermal energy extracted from the plasma is emitted in the form of photons in the surroundings where it dissipates, it results that total entropy is not changing. On the other hand, the power extracted from the PS during every period of oscillation is partly dissipated as heat in the circuit and as electromagnetic waves emitted in the surroundings when the oscillatory circuit works as an open system. The period, amplitude and shape of such a typical kind of oscillation sustained by an S-NDR proper to the plasma diode is marked by (1) in Fig. 3.

A more advanced state of self-organization of the plasma blob spontaneously emerges when the voltage of the PS is additionally increased at the value marked **e** in Fig. 1. In that moment, the current I collected by the anode abruptly decreases (branch **e-f**) and simultaneously the amplitude of the oscillations decreases at the half and their frequency increases at the twice. In Fig. 3 these oscillations are marked by (2). Investigating the cause of this abrupt transition, it was established that during these oscillations NSDLs periodically peel off and reform at the border

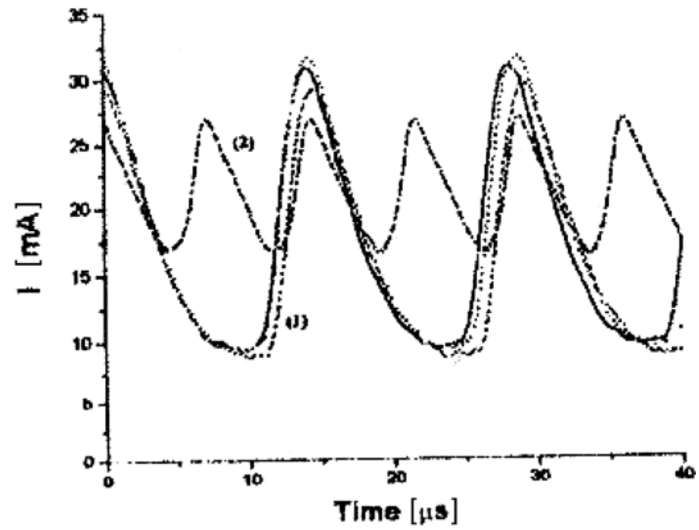

Fig. 3 – Shape and amplitude of the oscillations generated by S-shaped negative differential resistance (1) and N-shaped negative differential resistance (2).

of the plasma blob [9, 10]. During this dynamical state of the plasma blob there exist two time spans: (i) a time span where matter (positive ions and electrons) concomitant with electric field energy is transported from the border of the plasma blob into the surrounding plasma; (ii) another time span in which a new NSDL is self-assembling at its border by a mechanism that involves extraction of thermal energy from the surrounding plasma. In this way, the moving NSDLs perform mechanical work ensuring the existence of the plasma blob by a rhythmic exchange of matter and thermal energy from the surrounding plasma by a mechanism that also involves emission of photons. After its transition into a dynamical state the plasma blob survives in this state also when the voltage of the PS is gradually decreased (branch **f-h** in Fig. 1). This behavior of the plasma signifies that the nonlinear process marked by abrupt decreasing of I (branch **e-f**) acts as a new memory mark by which a new program was encoded. Based on this program the plasma blob attributes to the plasma diode the behavior of a Z-shaped instability that appears in the static $I(V)$–characteristic (when the PS voltage is only increased) as an N-shaped negative differential resistance. Important is the experimental proved fact that both types of negative differential resistance revealed by the plasma diode involve emission of photons, *i.e.*, they work extracting thermal energy from the plasma by a mechanism exploiting collective effects of quantum processes. This is in our opinion an experimental result that offers a new insight concerning the mechanism by which different kinds of negative differential resistance works [10, 12].

The sizes of the plasma blobs depend on the gas pressures. For the aforementioned pressures the sizes are in the order of centimeters. Bordered by an

NSDL the plasma blob behaves as a cavity able to absorb at resonance electromagnetic energy. This means that the electromagnetic waves emitted by a plasma blob during its dynamical state are absorbed at resonance by another plasma blob. So, the information can be exchanged between plasma blobs.

Additionally, as proved in our laboratory, by changing the “environmental” conditions by laser irradiation the dynamics of the plasma blob changes. So, as already proved, the dc gas discharge acts as a very sensitive sensor of changes produced by irradiation in the plasma in which it is located [13]. Emerged by self-organization in the so called microdischarges that work at pressures close to the normal pressures, the sizes of the plasma blob are in the range of nano/micrometers. So, we presume that blobs whose sizes are in the aforementioned ranges are able to absorb electromagnetic waves whose frequency is very high at extremis

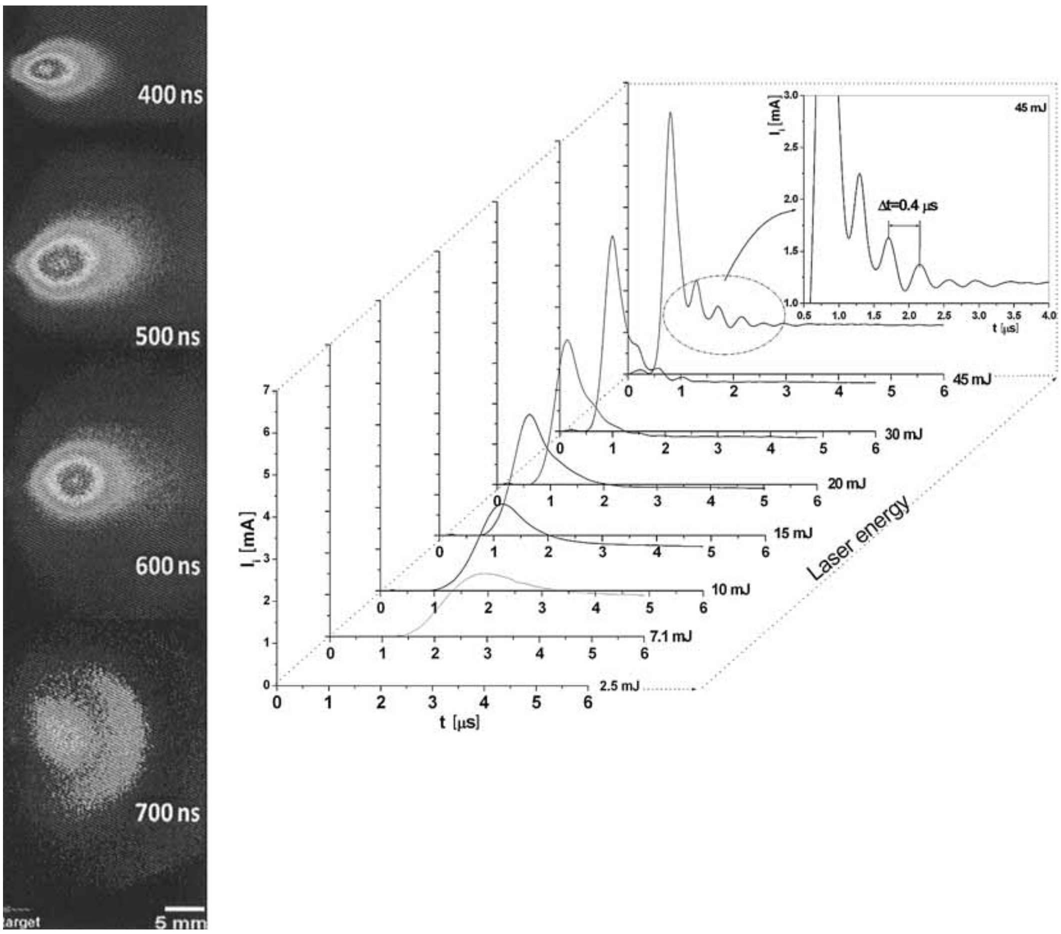

Fig. 4 – a) Evolution of a stable plasma blob generated by a 10 μs laser pulse into a dynamical state; b) ion current collected by a probe when the energy of the laser pulse is increased.

photons [3]. The presence of the above phases of self-organization was recently proved by generation of hot plasma by a 10 μs laser pulse (Fig. 4a) [14]. These experiments prove that by quick injection of energy hot plasma emerges at such a distance from thermal equilibrium that, instead to return into thermal equilibrium as the second law of thermodynamics requires, it evolves, in absence of any external driving forces, into plasma blob. The plasma blob transits into a dynamical state, fact revealed in Fig. 4a by the appearance of a luminous sheet that is peeled off from the plasma blob, when the injected energy becomes greater than a critical value. The evolution of the ionic current collected by a probe placed in the neighborhood of the plasma blobs is presented in Fig. 4b for different energies of the laser pulse. Note that the lifetime of the plasma blob is much longer than the duration of the laser pulse. This means that the plasma blob is able to maintain its existence as an autonomous entity by a mechanism involving emission of photons, *i.e.*, direct conversion of thermal energy in electric field energy.

4. ORIGIN OF BIOPHOTON EMISSION

Because life necessarily exists as cells, a membranous enclosure able to locate a microenvironment that differs qualitatively from the surroundings is life's first structural requirement. However, for living, the membrane must be able to ensure the self-existence of the cell performing operations by which a preferential exchange of matter and energy between the cell and the environment occurs. Until recently, it was assumed that channels whose function is related to their conformation control this exchange. This means that the channels exist in a few stable conformation states that switch rapidly between them [15]. These states were represented by: (1) a kinetic diagram consisting from a few conformation states and the transition probability between them; (2) an energy level model consisting of a few energy minima and the pathways between them. Data from biochemical experiments were used to compute the switching probability and their associated energy barriers between these different conformational states. The changes from shapes that open the channels to those close them for the passage of matter (ions) and energy can be emphasized by the patch clamp technique.

In this paper we start from the premise that self-organization is the single "technique" known by the Nature to create living systems and implicitly all of their structural components. From these components the most important one is the eukaryotic nucleus of the cell considered by us as the successor of an ancestor protocell created by an electric spark in a medium of the early Earth where water and organic matter were not present [3]. Emerged in the same way but in an environment where water and organic matter appeared, the hot plasma created by a spark initiates the emergence by self-organization of the electric skeleton (template) that act as a "electronic device" endowed with a flash memory. This skeleton acts as a mould for chemicals to conform with to form a primitive biological cell [3]. Endowed with a flash memory, the electric skeleton commands the further evolution into the first living unity namely the ancestor of the eukaryotic nucleus. So, immediately after its emergence by self-organization the first living unity lives by emission of biophotons. Possessing a code of information learned during its emergence by self-organization (similar to that of the plasma blob) the first living unity is able to encode new instructions offered in that case by an environment that contains water and organic matter so that nonlinear (enzymatic) reactions appear [3]. So it emerges the eukaryotic nucleus that locates intelligent matter (DNA, nucleic acids and others) protected from the surroundings by a rigid membrane. The possibility of such an evolution was recently proved by simulation methods [4]. For ensuring the continuity of the living process the membrane was traversed by channels. For explaining the opening and enclosing of these channels we started from the hypothesis [3] that a minuscule electric double layer (EDL) borders each channel. Resulted after division from an initially enclosed EDL every minuscule EDL possesses an algorithm of instructions encoded in its flash memory. This means that local fluctuations can determine the transition of the minuscule EDLs into a moving phase by a mechanism revealed by plasma experiments. Thus, transiting into a moving phase, the minuscule EDL transports matter and energy through the channels. Simultaneously, the minuscule EDL sustains a proper potential drop through a mechanism that involves extraction of thermal energy from the surroundings, a phenomenon that involves emission of biophotons. Living in a medium where molecular oxygen is present, the temperature required for ensuring the living process of a biological cell is ensured by additional chemical processes that involving oxidations limit the life of the cell [3]. The conversion of thermal energy extracted from the surroundings and also the thermal energy resulting after chemical reactions into electric field energy involves emission of biophotons.

Placed in a soup that contains different sorts of positive ions, the minuscule EDLs separate, during their moving phase, positive ions in the nucleus whose ionization potential is different from those placed in the surroundings. This is because the minuscule EDLs transit into a moving phase when their potential drop reaches the value corresponding to the lowest ionization potential. Since after transition into the moving phase a periodic succession of decaying moving minuscule EDLs transport matter and energy, the emitted biophotons that accompany this process actually have their origin in a special type of "oscillators". The oscillations are excited when the kinetic temperature and the thermal energy distribution function of the electrons have a certain critical value/shape so that this excitation mode could be actually considered as a so-called supra-thermal one [2]. The emission of biophotons becomes coherent when the minuscule EDLs start their moving state at the same moment. Such a phenomenon can be, for example, initiated by nonlinear (enzymatic) chemical processes that at their turns ca be initiated by internal as well as by external causes. Encoded in the informational content of the coherent emission of biophotons the effects of these internal or external causes are receipted at resonance by the surrounding cells. So the cell self-adjusts its activity in according with the obtained information.

5. CONCLUSIONS

Based on experiments proving that plasma blobs that "live" by emission of photons emerge by self-organization in plasma that does not contain water and organic matter, we consider the phenomena involved in this emission as elucidative for biophotons emission of biological cells. Essentially is the fact that the "machinery" by which the plasma blob exists as an inorganic living system [3] works by extracting thermal energy from the surrounding plasma. Acting as the template located in organic matter, the electric skeleton emerged by self-organization works as a mould for chemicals explaining in this way the self-assemblage of a biological cell. In this context the experimental results revealed by plasma experiment potentially suggest a new route for the so-called living technology whose attempt is to create an artificial cell [16].

Starting from the already expressed hypothesis that the opening and enclosing process of the eukaryotic nucleus channels is controlled by minuscule EDLs [3] we propose a new conceptual model for the ion channel dynamics. Since every minuscule EDL possesses a flash memory that is physically based on direct conversion of thermal energy into electric field energy, the dynamical state of the minuscule EDL involves emission of biophotons. This means that all minuscule EDLs act as potential oscillators. The simultaneous transition of the minuscule EDLs into the dynamical state initiated by so-called supra-thermal excitation (critical kinetic temperature and thermal distribution function of the electrons) potentially explains the coherence of biophoton emission. The Casimir forces invoked as channels informational have their origin in thermal energy extracted from the environment.

REFERENCES

1. F. A. Popp, Quantum phenomena of biological systems as documentated by biophotonics, in *Quo Vadis Quantum mechanics?*, Eds A.S. Dolev and N Kolenda, Springer, New York, 2005, 371.
2. G. J. Hyland, *Fundaments in coherence in biology*; http://www.biophotonic.de/abstract/abs2000-3.htm
3. E. Lozneanu, M. Sanduloviciu, *Self-organization scenario grounded on new experimental results*, Chaos, Solitons & Fractals, available at Science Direct 2007, doi:10.1016/j.chaos.2007.09.067.
4. V. N. Tsytovich, G. E. Morfill, V. E. Fotov, N. G. Gusein-Zade, V. Vladimirov, B. A. Klumov, S. V. Vladimirov, *From plasma crystals and helical structures toward inorganic living matter*, New Journal of Physics, **9**, 263 (2007).

5. D. Cohen, *Plasma blobs hint at new form of life*, New Scientist, **179**, 16 (2003).
6. H. Maturana, F. Varela, Autopoiesis and Cognition: the Realization of the Living, in: *Boston Studies in the Philosophy of Science*, **42**, Eds. R.S Cohen, M.V. Wartofsky, Dordecht, D. Reidel Publishing Co., 1980, 78.
7. E. Lozneanu, M. Sanduloviciu, *Self-organization scenario acting as physical basis of intelligent complex systems created in laboratory*, Chaos Soliton & Fractals, **30**, 125 (2006).
8. E. Lozneanu, V. Popescu, M. Sanduloviciu, *Negative differential resistance related to self-organization phenomena in a dc gas discharge*, J. Appl. Physics, **92**, 1195, 2002 (selected for republication in Virtual J on Nanoscience & Technology, **6**, 29, 2002).
9. D. Alexandroiei, M. Sanduloviciu, *Dynamics of double layers formed in the transition region between two negative plasma glows*, Phys. Let., A **122**, 173 (1987).
10. E. Lozneanu, S. Popescu, M. Sanduloviciu, *Plasma experiments with relevance for complexity science*, appeared in: *Unifying Themes in Complex Systems* Vol. IIIB, eds. A. A Minai, Y. Bar-Yam, Springer Verlag, USA, 2007, 119.
11. E. Lozneanu, S. Popescu, M. Sanduloviciu, *Plasma experiments with relevance for nonlinear behaviors of semiconductors*, Chaos, Solitons & Fractals, **17**, 243 (2003).
12. S. Popescu, E. Lozneanu, M. Sanduloviciu, *On the "mystery" of differential negative resistance*, appeared in *Unifying Themes in Complex Systems*, Vol. IV, eds. A. A. Minai, Y. Bar-Yam, Springer Verlag, USA, 2007, 213.
13. I. I. Popescu, M. A. Bratescu, M. P. Dinica, *A new plasma spectroscopic technique based on laser induced frequency shift of pseudosonic ion waves*, Spectrochimica Acta, **46B**, 547 (1991).
14. S Gurlui, M. Sanduloviciu, M. Strat, C. Mihesan, M. Ziskind, C. Focsa, *Periodic phenomena in laser ablation plasma plums: a self-organization scenario*, International Conf. PLASMA, Opole, Poland, September 6–9, 2005.
15. L. S. Liebovitch, P. Krekora, *The physical basis of ion chanell kinetics: The importance of dynamics*, http://www.ccs.fau.edu/~liebovitch/dyn.html
16. *** *Building an Artificial Cell*, PACE Complex System Lab. Website Toward Living Technology, http://complex.upf.es/~ricard/PACEsite