Exploration

The Emergence of Brain-Like Functions in Neuromorphic Metallic Nanowire Network

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Abstract

The article by Diaz-Alvarez et al published in Nature reports rather interesting findings suggesting that human brain-like functions emerge in neuromorphic metallic nanowire networks. There are also other findings suggesting that simple systems such as plastic balls can exhibit life-like properties. In this article the TGD inspired model for the latter findings is applied to neuromorphic networks.

1 Introduction

The popular article "*Human Brain-Like Functions Emerge in Neuromorphic Metallic Nanowire Network*" published in Scitechdaily (`http://tinyurl.com/v8a2pqg`) represents findings, which are very interesting from TGD point of view. The original article "*Emergent dynamics of neuromorphic networks*" by Diaz-Alvarez et al is published in Nature [1] (`http://tinyurl.com/v44rc62`). There are also other findings suggesting that simple systems such as plastic balls can exhibit life-like properties. In this article the TGD inspired model [4, 8] for these findings is applied to neuromorphic networks.

Consider first the findings.

1. One can say that the self-organization process corresponds to the system "struggling" to find optimal current pathways. This process involves fluctuations akin to those found in memorization, learning and forgetting processes of brain. The temporal flutuations also resemble the processes by which brain becomes alert or returns to calm.

2. The metallic Ag nanowires become coated with a polymer (PVP)(`http://tinyurl.com/tnmu4y9`) insulating layer with about 1 nm thickness. Also metallic junctions between two nanowires acting as a resistive elements analogous to synapse are formed. The average diameter and length of nanowires was measured to be 360 ± 110 nm and 14 ± 5 μm, respectively.

   Remark: These scales correspond to biological length scales (p-adic length scales $L(161)$ and $L(172)$).

3. There are suggestive connections with biology. PVP polymer is an organic compound with repetive active part which consist of two parts: CH_2 and aromatic Carbon 5-cycle with one C replaced with N and one CH_2 replaced with C=O. In TGD framework this could be relevant for the self-organization - maybe the magnetic bodies of PVP polymers are in an essential role. I have proposed that valence bonds correspond to flux tubes with effetive Planck constant $h_eff = n \times h_0 > h = 6h_0$ [3] (`http://tinyurl.com/ycg94xpl`).

4. The formation of low resistance pathways between probes contacting the networks induces a transition from low conductance state to high-conductance state at given voltage threshold usually below 10 V. This occurs even for millimeter distance between probes. The weak independence on voltage suggests that the current flow is almost dissipation free - could dark supra currents at magnetic flux tubes be involved?

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2 TGD based model

TGD predicts several a lot of new physics possibly relevant to the findings [10, 9] (`http://tinyurl.com/wd7sszo`) and `http://tinyurl.com/y3xbkokb`).

1. Magnetic flux tubes (magnetic body, MB) carrying dark matter as phases with effective Planck constant $h_{eff} = n \times h_0$.

2. Zero energy ontology (ZEO) allows to formulate quantum measurement theory without paradoxes. The possibility of time reversal is one dramatic prediction. Basic mental functions like memory would be completely universal phenomena and possessed in principle even by elementary particles. Both memory recall and motor action would involve "big" (ordinary) state function reduction (BSFR) changing the arrow of time. Biological death would correspond to BSFR.

   Sensory perception assignable to "small" state function reductions (SSFRs) identifable as correlates of "weak" measurements would not involve change of the arrow of time: the increase of distance between tips of causal diamon (CD) in each SSFR following unitary evolution would give rise to the experienced flow of time and correspondence between subjective time as sequences of SSFRs and geometric time as temporal distance between the tips of CD.

3. Universality of cognition described in terms of p-adic (adelic physics) is predicted [5, 6, 7] (`http://tinyurl.com/ycbhse5c` and (`http://tinyurl.com/yyyk6fu8`)). Number theoretic vision realized as adelic physics predicts evolution as increase of the dimension of extension of rationals characterizing basic building bricks of space-time as surface.

   Self-organization involves generation of coherence and requires energy feed [9] (`http://tinyurl.com/y3xbkokb`). Same applies to life. Self-organization would be also universal: the self-assembly aspect of self organization would be simply due dissipation at reverse time direction at the level of dark matter at magnetic body controlling the dynamics at the level of ordinary matter as master.

4. Quantum criticality is essential element of self-organization and the observed $1/f$ fuctuations could be interpreted as their signature. Note that $1/f$ fluctuations are observed also in the ordinary electric circuits and since also these involve self-organization aspects, dark matter in TGD sense might be involved.

   At quantum criticality long range fluctuations take place and correspond to the creation of phases with large h_{eff} and having therefore long quantum coherence length. Energy feed is however required and serves as analog of metabolic energy. Freezing of water could a good example about quantum criticality at the level of MB inducing ordinary criticality and leading to generation of complex structures at the level of ordinary matter. Snowflakes (`http://tinyurl.com/wg8fyth`) and the patterns observed by Emoto [12] (`http://tinyurl.com/ycdywctw`) as a response to stimuli like emotional voices provide examples of this.

The TGD based interpretation relies on the same ideas as the model for other findings about simple systems possessing lifelike properties [4].

1. The voltage feeds metabolic energy to the system by making current flow possible. The transition to high conductance state above critical voltage could correspond to minimal metablic energy feed needed to induce a phase transition generating Cooper pairs of electrons or even dark Ag ions with $h_{eff} > h$ at magnetic flux tubes so that current would become partially dark and conductance would increase. The preservation of dark phase requires energy feed but the reduction of dissipation for supracurrents makes this possible.

2. Ag^+ have cyclotron frequency of 2.8 Hz in "endogenous" magnetic field $B_{end} = .2$ Gauss assigned with living systems tentatively identified as the dark monopole flux carrying part of the Earth's

magnetic field with nominal value $B_E = .5$ Gauss. Are the Cooper pairs of these ions involved? What about electronic Cooper pairs with cyclotron frequency about .6 MHz? Could the Coulomb energy $E_c = ZeV$ for Cooper pair in critical voltage correspond to the cyclotron energy of the dark Ag^+ Cooper pair or of electronic Cooper pairs? Nottale hypothesis $h_{eff} = h_{gr} = GMm/v_0$ [2] is an essential part of the TGD based model of quantum biology [11] (`http://tinyurl.com/rw58zaz`) and would predict that cyclotron energies would not depend on the mass of the charged particle.

3. EEG is basic aspect of brain function of vertebrates. Could it be that Ag^+ ions and also the possible ionization of the aromatic cycles make possible analog of EEG around 2.8 Hz?

In this framework the findings discussed in the article could be assigned with system which are very simple life forms. To gain improved understanding a model for the magnetic body of the system would be needed.

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