Could computers be living and move?

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Abstract

The unique properties of water (in particular Pollack effect) play a key role in the TGD based quantum view of life. Liquid metals might however provide an alternative for water. Gallium is liquid above 29.5 C and has extremely nice properties concerning building of artificial life. Even doing the experiments possible at home, one can get convinced of the amazing lifelike properties of Gainstan (Ga, In and Si). Ga allows a generation of cell-like structures possessing the analog of membrane potential and the modulation of the conductivity of Ga by electric pulses is possible. There is an amazing amount of work already done but it is drowned to the AI hype.

TGD predicts a lot of new physics. The new view of space-time and quantum theory makes possible quantum coherence in arbitrarily long scales. TGD also suggests a universal realization of the genetic code, based on universal topological qubits possible in systems allowing cold plasmas and OH pairings (as also water).

This inspires the proposal that life is a universal phenomenon possible in systems allowing cold plasmas. The counterpart of DNA could be symbiotic pairing of ordinary bits and universally realized topological qubits taking place also in ordinary living matter.

Semiconductors are required for the hybrid of ordinary and quantum computers. It would also be highly desirable to have motor activities. GaP, GaN,GaAs allow 1-D semiconductivity but their melting point is very high. Could a compound involving Gal and OH in liquid phase act as an effective semiconductor making possible the hybrid of ordinary computer and topological quantum computer based on the OH–O^-+ dark proton qubit. Pollack effect might indeed make the generation of p and n type regions possible and the example of water supports this view.

Contents

1 Introduction

Not long time ago, I wrote several articles about the possibility of new life forms predicted by TGD involving in an essential way plasma phases [L4]. I also wrote a couple of articles about the possibility that TGD based quantum physics could allow ordinary computers be or become conscious [L8, L9].

The basic prediction was that systems behaving like cold plasmas are good candidates for living systems very much like ordinary living systems, which can be also regarded as cold plasmas with O^- ions created by kicking the ordinary proton of OH to a dark proton at the magnetic body of the system. OH and O^- + dark proton would define the states of a topological qubit. Dark protons at the field body could control the system. The basic mechanisms would be the Pollack effect and its reversal. In the Pollack effect a photon of visible light kicks the proton of OH to the field. This mechanism has several generalizations: for instance the needed energy for kicking would come from the formation of bound states and could have played a key role in the formation of biomolecules. Also other negatively charged ions produced in this way could be highly relevant.

OH-O^- + dark proton or its generalizations would define the counterpart of qubit making the system a hybrid of an ordinary computer paired with its dark variant, analogous to a quantum computer, whose ground state would correspond to a bit sequence for an ordinary computer.

TGD inspired quantum biology suggests that exactly the same mechanism works for DNA in the living system and here phosphate ions would play a key role. In this case, OH-O^- + dark proton qubits allow a realization of genetic code. TGD predicts a universal realization of genetic code in terms of tessellations of hyperbolic 3-space (mass shell of proper time constant hyperbolic of light-cone) [L3]. Pollack effect is also key step in photosynthesis.

The problem with the idea of living computers seemed to be that living metals differ from biosystems in that they lack motor activities altogether. It did not occur to me whether liquid metals could be considered. If I had done this, I would have taken five minutes to find that Caesium, Rubidium, Mercury and Gallium are exceptions: the melting temperatures are 28.5 C for Caesium, +40 C for Rubidium, -38.8 C for Mercury and 29.76 C for Gallium. Gallium has a very wide range of temperatures for liquid state: it boils at 2,204 C! This temperature corresponds to energy of .248 eV

2 Two discoveries supporting the notion of metal life

In the following I describe two discoveries supporting the notion of metal life. First discovery by Liu et al, if real, would support Gallium based liquid life with motor abilities and second discovery of Cronin et al gives strong indications for cellular metallic life.

2.1 The work of Jing Liu et al related to living liquid metals

The next question would have been whether anyone might have tried to engineer something like liquid metal life. To my great surprise, I learned that Chinese engineers have developed what could be called living metal (see this). Unfortunately, the FB posting did not give the link the orginal article but I glue the short posting here.

The following is the popular article telling about a later article, which I failed to find.

A real liquid metal that can think, change shape, and compute like a brain In a discovery straight out of science fiction, engineers at the Chinese Academy of Sciences have created a liquid metal alloy that can store information, compute logical operations, and morph shape all at room temperature.

The alloy is based on gallium mixed with rare earth elements, and what sets it apart is its internal programmable conductivity. When stimulated with tiny voltage pulses, it rearranges its internal atomic structure and remembers past inputs functioning like a primitive neural network.

This is not just a switch or sensor. It s a soft, deformable material that can perform computations while flowing, adapt its shape around barriers, and even react to past stimuli like a metallic brain in motion.

During lab tests, droplets of the liquid metal could solve simple logic gates, recognize patterns, and change course in a maze based on prior inputs. The alloy also exhibits self-repair, reconnecting *broken pathways automatically.*

It s the first hint of true material intelligence the idea that matter itself can think, store data, and interact with its environment without needing silicon or rigid electronics. This could reshape robotics, adaptive prosthetics, and soft-body machines that move and learn like living organisms.

We're watching the birth of sentient materials wet, metallic, and quietly learning.

2.1.1 Galinstan as an example of living metal

There is a nice web page (see this) giving some idea about what the statement that Ga is living could mean. The experiments that anyone can perform at home involves Galinstan, which is a mixture of post-transition metals Ga, In and Si, having $Z = 31, 49$, and 50. As post-transition metals, Ga, In and Si are next to the filled d-orbital with 10 electrons and have a partially filled p-shell.

Galinstan droplets are added into water and $CuCl_2$ is added and CuO(s) having a black color is formed. The reaction that occurs is $3Gal(s)+3CuCl_2 \rightarrow 3Cu(s)+ 3GaCl_3(aq)$ followed by $2Cu(s)+O_2 \rightarrow 2CuO(s)$. As a consequence,the surface tension of the droplet is reduced and it spreads. If the surface tension is dropped locally at the surface of the droplet, appendages are created. The addition of HCl(aq) induces the reaction $CuO(s) +2HCl(aq)\rightarrow CuCl_2(aq)+H_2O(l)$.

If the droplet is put into a maze and also $CuCl_2$ is added, the droplet decomposes to worm-like pieces and starts to move and "eat" the $CuCl_2$ serving as a "food" and produces CuO(s). These worm-like pieces follow the food and go through the maze as if they were intelligent living entities.

2.1.2 The articles of Liu et al about living metals

I am grateful for Antonio Manzalini who kindly sent me a link to a popular article (see this), which probably relates to this discovery. The article tells about the work of Jing Liu et al., "Liquid Metal Memory" published in Advanced Materials (2023) [D1].

I managed to find a link to a theoretical article by Liu et al [I3]. The following list given in the introduction of the article gives some idea of how far the study of artificial living matter has advanced.

1. Enzyme-containing metal-organic frameworks are wrapped as artificial organelles to assist in cellular functions.
2. Humidity-responsive and thermal-responsive biomimetic artificial muscles with helical structure.
3. A bionic octopus arm that can reach, sense, grasp, and interact.
4. Entirely soft autonomous robot assembled from multiple materials through integrated design and rapid manufacturing approach.
5. Biosimilar liquid-metal living matter, liquid-metal virus, Liquid-metal red blood cells and blood vessels, liquid-metal liver, liquid-metal fish.

Here is the abstract of the article.

"Breaking away from the long journey of natural selection to create biology-resembling living matter is exceedingly significant for understanding life and thus better enhancing the quality and length of human life. Among various potential ways to approach such a long-standing goal, liquid metals and their extended composites are providing rather promising answers. Here, we systematically present a basic framework and concept of liquid-metal living matter toward making biology-like objects through fully bringing out their unusual physical, chemical, and biological capabilities. The logical clues and technical approaches to achieve liquid-metal living matter were screened out in analogy to biological counterparts by following their sizes, structures, and functions spanning from cells, tissues, and organs to organisms. We first clarify biomimetic roles that liquid metals have exhibited in their autonomous behaviors and biotaxis to external fields. Then, we explain how to adopt liquid metals and their derivatives to form various liquid-metal cells, which could aggregate into corresponding tissues. Further, structural designs and combinatory integrations are suggested

to realize liquid-metal organs and even biomimetic life. Finally, perspectives on applying liquid-metal living matter to construct artificial life are given, which warrants tremendous research and application opportunities in the future."

2.2 The work of Lee Cronin et al related to iCHELLs

I decided to check whether something like this has been tried by anyone else. I found popular articles about the work of the team of Lee Cronin at the University of Glasgow related to living metals (see this or this). Here is the abstract of an article published in 2010 [I1]:

"Self-assembly has proven a powerful means of preparing structurally intricate nanomaterials, but the mechanism is often masked by the common one-pot mixing procedure. We employed a flow system to study the steps underlying assembly of a previously characterized molybdenum oxide wheel 3.6 nanometers in diameter. We observed crystallization of an intermediate structure in which a central {Mo36} cluster appears to template the assembly of the surrounding {Mo150} wheel. The transient nature of the template is demonstrated by its ejection after the wheel is reduced to its final electronic state. The template s role in the self-assembly mechanism is further confirmed by the deliberate addition of the template to the reaction mixture, which greatly accelerates the assembly time of the {Mo150} wheel and increases the yield."

The following short abstract summarizes the work the second article of Cronin et al [I2](see this). Unfortunately, the article is behind the paywall.

"Interfacial membrane formation by cation exchange of polyoxometalates produces modular inorganic chemical cells with tunable morphology, properties, and composition (see picture). These inorganic chemical cells (iCHELLs), which show redox activity, chirality, as well as selective permeability towards small molecules, can be nested within one another, potentially allowing stepwise reactions to occur in sequence within the cell."

To understand the work of it is good to list some basic concepts.

1. Transition metals (see this), which are in periods 4,...,7 of the periodic table, are used. Molybdenum (Mo) is the one used in the first work.

2. Metallates (see this) are compounds involving metal bound to several ions, which are negatively charged oxygen ions so that one talks of polyoxometalates. Examples of oxometalates are $\mathrm{MnO_4^-}$,$\mathrm{CrO_4^{2-}}$, $\mathrm{V}O_3^-$ or $\mathrm{VO_4^{3-}}$, $\mathrm{WO_4^{2-}}$. Also thio-,seleno-, telluro,- cyano-,... etc metallates are possible. Oxometallates have oxyanions (see this) as building blocks. Polyoxometalates (see this) consisting of several oxyanyons for which the general formula is $A_xO_y^{z-}$. Their protonation produces Oxyacid $HA_xO_y^z$.

   An interesting question, inspired by the notion of topological OH-$\mathrm{O^-}$ + dark proton qubit is whether this transition and its reverse can also have variants in which a proton of the oxyacid is transformed to a dark proton at the field body or vice versa.

3. Phosphates PO_4^{3-}, playing a key role in biology, are analogs of oxometallate. P is not a metal but can have besides the naively expected oxidation state -3 (3 missing valence electrons) also oxidation states +3 and +5 so that it behaves like a metal. Transition metals have typically oxidation state +3.

Cronin et al introduce the notion of iCHELL as an analog of cell membrane.

1. iCHELL is formed in aqueous environment in presence of two kinds of salts. The first salt is formed from (oxyanions), which are large negative ions of transition metals such as tungsten W, usually belonging to group 6 and light positively charged ions such as $\mathrm{H^+}$ and $\mathrm{Na^+}$, which both behave like metal in this situation.

   The second kind of salt is formed from large positively charged organic ions and light negatively charged ions such as $\mathrm{Cl^-}$. The organic ion could be phosphorus, which can behave like a metal and become positively charged.

2. When the solutions of these salts are mixed, self-organization takes place and the salts exchange parts so that large metal oxides pair with the large organic ions. This new salt is insoluble in water: it precipitates as a shell, iCHELL, around the injected solution. For

instance, salt formed from a large negatively charged oxyanion and large positively charged organic ion and light ions Na^+ Cl^- can emerge. iCHELLs have a metal oxide backbone. An analog of cell membrane isolating its interior from the exterior is in question. Membrane potential characterizes it.

The experience with ordinary biology raises questions.

1. Could one imagine cell organelles: iCHELLs within iCHELLs?
2. Is a selective transfer of chemicals through iCHELLs possible: this would allow a control of chemial reactions. It is indeed possible to generate holes in membrane acting as ion channels. There are also some indications that proton pump transferring protons through the membrane is possible.
3. What about photosynthesis: is the splitting of water into hydrogen ions, electrons, and oxygen, the first step of photosynthesis, possible? Light-sensitive ties linked to metal oxide molecules as analogs of photoreceptors.
4. What about DNA and genetic code?
5. Evolution and pH dependent survival of fittest? TGD suggets that pH coulda actually correspond to the density of dark protons.
6. Is inorganic metallic life based on the same principles as the ordinary life possible?

Could the TGD based quantum model of living systems relying on water serve as a guideline for speculations?

1. Water is involved also now and could have an important role. The basic form of Pollack effect occurs in the presence of a gel phase negatively charged regions of water (exclusion zones (EZs) able to remove impurities inside them). Oxyanyons can be transformed to oxyacids by the reversal of the Pollack effect [L6, L1, L5].
2. The system can be regarded as cold plasma and cold plasmas are in a key role in TGD view of the role of the TGD counterparts of classical electric, magnetic, and gravitational fields in quantum biology [L2, L4]. The generalization of the Pollack effect in which the binding energy liberated in the formation of organic or other molecules leads to self-organization creating new more complex molecules by driving protons to dark protons at the field body of the system. Could this kind of mechanism explain the formation of iCHELLs?
3. Could OH-O^- + dark p give rise to a topological qubit [L8]? Could the energy difference between these two states of qubits correspond to a voltage and could external voltage pulses modify this voltage so that Pollack effect or its reversal become possible and allow the flip the qubit?

   Could the oxyanion side of the membrane give rise to 2-D structure consisting of bits and associated qubits?
4. Can one imagine a counterpart for DNA and genetic code? TGD suggests that genetic code has a universal realization in terms of a completely unique tessellation of hyperbolic 3-space (mass shell or cosmic time constant hyperboloid of CD), which involves 3 platonic solids instead of ne (tetrahedron, octahedron, and icosahedron having triangular faces) [L3] .

   This tessellation can induce besides 1-D realizations also 2-D and even 3-D realizations also at the level of cell membrane as a 2-D realization. Could the OH-O^-+p qubits assignable to the oxyanyon backbone provide a dynamical 2-D realization of the genetic code in the same same way as OH-O^-+p qubits they might do in the case of ordinary DNA and perhaps also ordinary cell membrane.
5. What is the role of positively charged organic ions? It is needed to create the analog of membrane potential. Could it also play a role similar to that of gel phase in the Pollack effect? Cells and also DNA are negatively charged. If negatively charged ions are in the

interior of the membrane, one might say that this is the case now. On the other hand, DNA is negatively charged at the outer surface (phosphate ions). Perhaps, a more plausible option is that the water generates negatively charged EZs in the Pollack effect creating the dark protons at the field body.

6. Could the TGD based quantum model of neuronal and cell membrane [L7] as a generalized Josephson junction with dark protons and ions forming Cooperpairs, serve as a guideline? In this model, proton pump involves Pollack effect and its reversal. The communications of the cell membrane to the magnetic body of the system would occur by Josephson radiation, whose frequency is proportional to the harmonic of the membrane potential ($f = eV/h_{eff}$). The huge value of the effectively Planck constant h_{eff} makes possible very low frequencies, such as EEG frequencies. The membrane potential and therefore also the Josephson frequency is modulated by the environment. Josephson radiation induces cyclotron transitions at the field body when the Josephson frequency equals the cyclotron frequency and analogs of nerve pulse sequences are generated giving possibly a response to the information sent to the field body.

Could these exotic life forms be already present in the biosphere and live in symbiosis with the ordinary life? Ocean bottom contains rare minerals (, which include transition metals) and also rare earth metals which appear as nodules of size scale about 5 cm. Polymetallic nodules, known also as manganese or ferromanganese nodules (see this) are mineral concretions composed of silicates and insoluble iron and manganese oxides formed of concentric layers of iron and manganese hydroxides around a core. They form on the seafloor and terrestrial soils. The formation mechanism are known to involves a series of redox oscillations driven by both abiotic and biotic processes. The nodules have a high abundance of nickel, copper, manganese, and other rare metals. The recent technology needs these metals and the most recent environmental risk is that the ocean bottom becomes the source of these minerals.

Manganese (Mn) (see this) is a transition metal with $(A, Z) = (55, 25)$. Its electronic configuration is [Ar] 3d5 4s2. Transition metals have a large number of oxidation states ranging typically from +2 to +7. Also Mn has a very large number of oxidation states +2, +4, +7 3, 2, 1, 0, +1, +3, +5, +6 so that it is chemically very complex. The presence of 4s and 3d orbitals make them able to form a large number of compounds. Iron has oxidation states +2 and +3 and less commonly, +4,+6,+7.

The metal oxides involved contain OH^- ions: could they have formed by Pollack effect for water kicking protons of water molecules to dark protons at the field body. Could manganese modules be an outcome of the symbiosis of rare metal based primitive life forms with ordinary organisms.

3 About the TGD view of living metals

The article says that Ga has a programmable conductivity. Tiny voltage impulses control the conductivity just like in transistors. TGD predicts a mechanism of control relying on the modification of the energy difference between states OH and O^- + dark proton at monopole flux tube defining qubit [L8, L9]. This energy difference can be controlled by external voltage pulses and the system can be driven near criticality against the flip of the qubit. Note that besides this particular realization also other realizations of qubit are possible.

As a metal-liquid Ga allows a formation of cell-like structures having a core surrounded by an oxidized layer and the core might play the role of information processor analogous to DNA.

The basic question is how to obtain a semiconductor involving Ga and at the same time possessing hydroxides OH for which OH $\leftrightarrow O^- + p$ (p dark proton) qubit is possible.

Ga is a metal and it seems that Ga alone cannot act as a semiconductor. One might hope that Pollack effect creating OH $\leftrightarrow O^- + p$ (p dark proton) qubits could come to rescue.

3.1 Some facts about Ga and rare earth elements

To discuss the findings described in the popular article about the findings of Liu et al some basic physical and chemical facts about Gallium and rare earth elements are in order.

1. Gallium is in the period 4 of the periodic table and has 1 p electron at the 4:th shell (see this and this). Ga is so called post-transition metal.
2. As already noticed, Ga melts at 29.76 C. Gallium is a semiconductor. Gallium nitride GaN and indium Gallium nitride as a mixture of GaN and InN are used in electronics. Also blue and violet light-emitting diodes and diode lasers use Gallium.
3. For Ga the oxidation state defined as the hypothetical charge of an atom if all of its bonds were fully ionic is predominantly +3 but also +1 is possible. This means that Ga tends to donate electrons. Interestingly, phosphorus P, playing a key role in biology, having oxidation states besides the naively expected -3 also +3, +5 are possible. For +3 and +5 P behaves like a metal. Also other oxidation states are possible for P. Clearly, the chemical complexity of P seems to be highly relevant to biology.

   Rare earth elements typically exhibit a trivalent (+3) oxidation state, but some can also be found in divalent (+2) or tetravalent (+4) oxidation states under specific conditions.

3.2 Questions inspired by the findings of Cronin et al

The experience with ordinary biology combined with the findings of Cronin raised several questions.

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3.3 Ga based semiconductors

Consider first the conservative option for semiconductivity. Ga is not a semiconductor and should be combined with some other element to make a semiconductor. There are several semiconductors involving Ga. The simplest ones are GaN, GaP, GaAs , GaSb. Also gallium oxide Ga_2O_3 is a semiconductor (see this.

One should modify these in such a way that one obtains OH groups. The basic problem is that all these compounds have rather high melting points. Despite this one can ask whether one could modify GaX (X= $\{P, N, As, Sb\}$) without losing the semiconductor property. OH group(s) should be added and also the replacement X→ XH_2 is suggestive.

1. One can start from gallium hydroxide $Ga(OH)_3$ (see this) obtained by adding ammonia to Ga^3+ salts. Gallium hydroxide is in the gel phase, which is interesting since gel phases are general in biology. It is also amphoteric so that it can act as both acid and base. Amino Acids are amphoteric: this is due to the presence of base NH2 and acid COOH. Also DNA is amphoteric.

   Google research gives an AI summary telling that the replacement of hydroxyl group (OH) with amine group (NH_2) is a standard operation in chemistry although it requires intermediate steps since the direct cleavage of OH is not easy. Also the replacement with PH_2 group or AsH_2 group is possible. It is in principle possible to replace one or two OH:s with NH_2:s. $GaNH_2(OH)_2$ would be a candidate for a semiconductor allowing single OH-O^-+ dark proton qubit.

2. This modification could however lead to a loss of the semiconductor property in 3-D case. The change of the chemistry could change the lattice structure or even lead to its loss. The band gap between valence band and conduction band would be affected. For GaN, one of the 3 valence electrons of Ga shared with N is transformed to a conduction electron for GaN. For $GaNH_2(OH)_2$ this should take place for the valence electron shared by Ga and NH_2. Ga has electronic configuration $[Ar]3d^{10}4s^24p^1$ and the delocalization of p-electron is expected to be relevant for semiconductor properties. A good guess is that this electron is shared with N also in $GaNH_2(OH)_2$ and the remaining 2 s^2 electrons of Ga would be shared with $(OH)_2$.

3. The change of the lattice structure induced by the replacement $N \rightarrow NH_2$ could affect the gap energy of GaN, which for semiconductors is typically near 1 eV. How do the details of the chemistry affect the lattice structure, in particular the lattice constant? What happens to the lattice lattice bonds between GaN molecules in the replacement GaN →$GaNH_2(OH)_2$?

   The Google search gives an AI overview telling that chemical modifications can significantly impact on the lattice structure and its properties. These modifications can alter molecular packing, vibrational modes, and overall stability, leading to changes in electronic, mechanical, and thermal behavior. In particular, lattice constant and gap energy can be modified.

4. Could the 3-D lattice structure be replaced with 1-dimensional lattice structure as in the case of DNA and amino acids? This might allow a realization of hybrids of the analogs of classical computers and quantum computers along the lines discussed in [L8] and perhaps even a linear realization of the genetic code based on its universal realization [L3].

   One-dimensional semiconductors involving GaX, $X \in \{P, N, As, PN\}$ are indeed possible (see this). In this case, the addition of analogs of side chains need not affect the 1-D lattice in an essential way and semiconductor property would not be lost. Also the functionality would be maximum unlike for 2-D or 3-D lattices. For instance, phosphates could occur as a parallel chain as in DNA strand and give a realization of dark genetic code in terms of OH–O^-+ dark proton qubits analogous to that proposed in TGD inspired quantum biology.

3.4 Could the Pollack effect make possible analogs of semiconductors?

Could the Pollack effect allow us to build effective Ga semiconductors and even transistor-like elements? Electrons and holes are essential for semiconductors. In n (p) type regions electrons doping is by atoms for which the number of valence electrons is larger (smaller) than atoms or molecules considered. In p type regions, doping is by atoms for which the number of valence electrons is smaller. $Ga(OH)_3$, which is in gel phase, is an excellent candidate for the semiconductor of this kind.

Pollack effect creating O^-+ p from OH creates negatively charged exclusion zones (EZs). The delocalization of the negative charges of O^- ions as conduction electrons could give rise to an analog of n doping. In the presence of electric fields , these electrons can be removed from the EZ.

The dropping of the dark protons back to ordinary protons giving rise to O^+ ions would give rise to p-type doping. In the case of water this would create OH_3^+ ions responsible for the pH of water. This might give rise to np type junction and one can even imagine analogs of npn and pnp type transistors. These transistors would be dynamical and the ordinary bits and OH-O^-+ p qubits would be very closely related.

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