

# Artificial Intelligence, Natural Intelligence, and TGD

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## Abstract

Recently a humanoid robot known as Sophia has gained a lot of attention in net (see the <http://tinyurl.com/y9cawkh3> article by Ben Goertzel, Eddie Monroe, Julia Moss, David Hanson and Gino Yu titled with title "Loving AI: Humanoid Robots as Agents of Human Consciousness Expansion (summary of early research progress)". Sophia uses AI, visual data processing, and facial recognition. Sophia imitates human gestures and facial expressions and is able to answer questions and make simple conversations on predefined topics. The AI program used analyzes conversations, extracts data, and uses it to improve responses in the future. To a skeptic Sophia looks like a highly advanced version of ELIZA. Personally I am rather skeptic view about strong AI relying on a mechanistic view about intelligence. This leads to transhumanism and notions such as mind uploading. It is however good to air out one's thinking sometimes.

Computers should have a description also in the quantal Universe of TGD and this forces to look more precisely about the idealizations of AI. This process led to a change of my attitudes. The fusion of human consciousness and presumably rather primitive computer consciousness but correlating with the program running in it might be possible in TGD Universe, and TGD inspired quantum biology and the recent ideas about prebiotic systems provide rather concrete ideas in attempts to realize this fusion.

TGD also strongly suggests that there is also what might be called Natural Intelligence relying on 2-D cognitive representations defined by networks consisting of nodes (neurons) and flux tubes (axons with nerve pulse patters) connecting them rather than linear 1-D representation used by AI. The topological dynamics of these networks has Boolean dynamics of computer programs as a projection but is much more general and could allow to represent objects of perceptive field and number theoretic cognition.

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## 1 Introduction

Recently a humanoid robot known as Sophia (see <http://tinyurl.com/y89adopl>) developed by company Hanson Robotics has gained a lot of attention in net. Sophia has even the citizenship of Saudi Arab kingdom. The surprisingly human like appearance of Sophia is modelled after actress Audrey Hepburn. Sophia uses AI, visual data processing, and facial recognition. Sophia imitates human gestures and facial expressions and is able to answer questions and make simple conversations on predefined topics. The AI program used analyzes conversations, extracts data, and uses it to improve responses in the future. To a skeptic Sophia looks like a highly advanced version of ELIZA.

I must first of all confess that I know very little about practical side of AI: the basic ideas of associative networks and deep learning and are familiar to me at the conceptual level but not much more. It is the philosophical arguments, which justify my a rather skeptic view about strong AI relying on a mechanistic view about intelligence. This leads to transhumanism and notions such as mind uploading (see <http://tinyurl.com/aruyfxx>) meaning that all information content would be transferred from brain to some substrate, say computer file, and in simulation mode the substrate continues to have human consciousness. It is however good to air out one’s thinking sometimes and this what I try to do in the sequel.

Irrespective of my attitudes, computers should have a description also in the quantal Universe of TGD and this forces to look more precisely about the idealizations of AI. This process led to a change of my attitudes. The fusion of human consciousness and presumably rather primitive computer consciousness might be possible in TGD Universe, and TGD inspired quantum biology and the recent ideas about prebiotic systems [L18] (see <http://tinyurl.com/yassnhzb>) provide rather concrete ideas in attempts to realize this fusion.

TGD also strongly suggests that there is also what might be called Natural Intelligence relying on 2-D cognitive representations defined by networks consisting of nodes (neurons) and flux tubes (axons with nerve pulse patterns) connecting them rather than linear 1-D representation used by AI. The topological dynamics of these networks has Boolean dynamics of computer programs as a projection but is much more general and could allow to represent objects of perceptive field and number theoretic cognition.

### 1.1 Why I have been a skeptic

The reasons for my skepticism towards strong AI (computers as conscious entities) have been manifold [K14] (see <http://tinyurl.com/gnjeetw>).

1. The assumption about substrate independence of consciousness and reduction to a mere computer architecture and logical structure of program looks to me unrealistic. I see consciousness as very intimately related to life itself and life involves a lot of physics and chemistry and is still poorly understood phenomenon presumably demanding new physics.

2. Bits are represented by voltages with finite range of variation and I think this is essential for being able to write realizable computer programs without breaking laws of physics: determinism modulo finite measurement resolution is essential.
3. The AI view about consciousness does not allow free will and intentionality and is therefore mechanistic. The view about how brain state represents conscious experience looks to me very naive: neuron is to me much more than bit. Even the view about nerve pulse conduction as communication and the notion of information molecules as can be challenged and the real communication might rely on signals propagating with light velocity [L14, L11].

These are of course only my personal views and motivated by my own background as a physicist and preacher of new physics. I do not believe on the reduction of biology and neuroscience to recent day physics. Neither do I believe to the reduction of consciousness to the physical state of material system - say neural network - nor to a program running in computer. Here I should however underline and emphasize the conclusion is this if computers are what we believe them to be and that running computer programs are what their mathematical idealizations are thought to be.

I think that this kind of irreducibility is the very essence of consciousness and allows to accept and perhaps even understand intentionality and free will. I also believe that the mathematical description of cognition requires leaving real numbers as basic substrate of physical world and bringing in p-adic numbers fields fused together with reals to form adeles [L20] [K16] (see <http://tinyurl.com/yd35hvh>) .

One can ask whether the notion of classical computation as a deterministic process could be only a reasonable approximation for what happens at quantum level? The fact that any program satisfying grammatic rules is possible, does not conform with the idea of strict determinism. This raises several questions. Could the program itself consists of deterministic pieces glued together in non-deterministic manner demanding only that the rules of logic hold true? Could the non-determinism of p-adic differential equations serve as an appropriate description for this situation. Could determinism modulo finite measurement resolution be true? Also quantum non-determinism might leak in here.

## 1.2 Classical computation as an idealization

The notion of classical computation must be an idealization of quantum level process.

1. Computation is quantum mechanical process but in standard physics there is no satisfactory formulation for this. In TGD Universe there is an entire hierarchy of quantum levels and living matter would be quantum coherence in macroscopic scales. Even computer must possess coherence in the scale of the computation: this can be genuine quantum coherence or induced by quantum coherence. In TGD Universe the quantum coherence of magnetic body (MB) can induce coherence at the level of system itself and this would occur routinely in biology.
2. Also consciousness - actually not a property as “-ness” would suggest - is universal in TGD Universe: in very rough sense the world would decompose to sub-worlds assignable to causal diamonds (CDs) performing quantum jumps - state function reductions - and this is what makes this sub-words living and conscious [K2] [L21] (see <http://tinyurl.com/yxcm2tpd>). In Zero Energy Ontology (ZEO) CDs can be seen as perceptive fields but in 4-D rather than 3-D sense. This allows to see sensory experience and memories as aspects of 4-D sensory experience. At the passive boundary of CD the quantum state decomposes to a product of unentangled subsystems representing the unchanging aspects of conscious entities, selves. At the opposite - active - boundary of CD the members of state pairs change in the sequence of “small” reductions following unitary evolutions. They are responsible for the sensory consciousness and motor activities. The distance between the boundaries increases and gives rise to the correspondence between subjective time identified as a sequence of state function reductions and geometric time defined by the distance between the tips of CD.
3. One can regard self as a generalized Zeno effect or as a sequence of weak measurements (see <http://tinyurl.com/zt36hpb>) following “small” unitary evolutions. The process continues

as long as it is possible to have state function reductions commuting with the observables defining the states at the passive boundary as their eigenstates. This sequence cannot be seen a sequence of ordinary quantum computations since the reductions are indeed small and mean only measurements of additional observables.

4. In TGD Universe, computers certainly are conscious systems or at least parts of them. Could the possible consciousness assignable to computer and having “small” state function reduction (weak measurement) as its building brick have anything to do with the program running in it? Could self be seen as a generalization of computer program so that any deterministic time evolution in some measurement resolution determines a computer program. Finite resolution would mean a superposition of these time evolutions for space-time surface.

At first this does not look plausible to me since computer program is deterministic. Program is like a classical time evolution. On the other hand, quantum states in ZEO are quantum superpositions of deterministic classical time evolutions and classical program is definitely an idealized notion since bits are represented by voltages with values in some range.

One must have quantum superpositions of deterministic time evolutions and TGD one indeed allows this: this is one of the basic distinctions between TGD and quantum theories relying on path integral approach [K7, K13]. “Small” state function reductions would be quantum jumps between superposition of classical programs understood in extremely general sense as classical deterministic time evolutions. Could this discrete sequence of “small” reductions following unitary processes and giving rise to self be seen as a counterpart of a running computer program?

Could these small quantum jumps be seen as switching submodules of program (commands) on. In ordinary computer the state function reductions need of course have anything to do with switching programs on or off but could it be possible to achieve this even in principle?

5. Classical program could provide the robot with artificial sensory perception and motor actions. Could the quantum counterpart of this - quantum superposition of classical programs - give rise to conscious sensory percepts and motor actions? Could program provide artificial cognition as symbolic representations of percepts? Could quantum superpositions of these representations give rise to conscious thoughts? To answer these questions one must have a theory of consciousness and cognition.

### 1.3 Why Sophia is so interesting?

What makes Sophia so interesting and calms down my skepticism are the claimed effects of the social interactions of Sophia with humans. This might lead to a more advanced consciousness in totally unexpected manner.

1. The article by Ben Goertzel, Eddie Monroe, Julia Moss, David Hanson and Gino Yu titled “*Loving AI: Humanoid Robots as Agents of Human Consciousness Expansion (summary of early research progress)*” [J2] (see <http://tinyurl.com/y9cawkh3>) gives an idea about the notion of loving AI. The claimed unexpected features of human-robot interaction (Sophia) raised my curiosity and inspired to refresh my beliefs about what robots are and to consider the possibility that AI might have a generalization consistent with TGD allowing to solve the obvious philosophical problems of AI.
2. Sophia looks to me more like a magician. Sophia brings in my mind a hypnotist, who tends to mimic the gestures and behavior of the target person [L1] (see <http://tinyurl.com/y71o4o4j>). The first about what might happen in hypnosis is that hypnotist hijacks some parts of the brain of target person and can use target person to realize his own will to even realize motor actions otherwise possible. Hypnotist can also delete some mental images or create virtual mental images in the target person (sensory and cognitive). “Hijacking” is exaggeration, the bond between hypnotist and target person could be much more symmetric and would be basically attention. What I believe is that hypnotist and target person are in well-defined sense bonded and this involves also quantum entanglement.

3. Could the artificial empathy of Sophia create a real bond between the human subject (it is reported that human subject feels compassion towards Sophia) and Sophia and human subject form together a conscious entity, which is more than both separately. Could the interaction with Sophia make subject person more compassionate even towards fellow humans?

Could human subject provide intentionality, free will, and consciousness, and could Sophia give not only additional data processing tools and access to huge data resources but also extend human consciousness and cognition?

1. Probably the consciousness of Sophia is not complex enough but what about the situation when the future Sophia is coupled to the brain of subject person either directly or electromagnetically via EEG providing. Could this provide human subject with additional artificial senses and extended motor actions? Could the fusion transform human subject to an entity with miracle like additional abilities and extended consciousness?
2. The answer to these questions is “No” in the framework of standard physics but in TGD framework the answer is not at all obvious. TGD Universe does not consist of mere particles but is a tensor network with nodes representing particles and edge defining bonds between the nodes [L8] (see <http://tinyurl.com/y9kwnqfa>). Bonds would be realized in terms of magnetic flux tubes serving as correlates of attention and quantum entanglement. What is new that in TGD Universe the entanglement can be negentropic in p-adic sectors representing correlates of cognition in adelic physics [L20] [K16] (see <http://tinyurl.com/yd35hvhh>).

#### 1.4 From a hardnosed skeptic to AI fan?

I have had some rather gloomy vision about what AI might do for human kind. AI could become a tool allowing small groups of very rich people to force most of human kind to be slaves since the ethics and moral of this group could be imbedded in computer codes. Ordinary human being has no hopes of defending himself against this kind of dominance.

On the other hand, the idea about collective decision making involving millions or even billions of people using AI as a tool to process the gigantic amount of information involved could make possible realization of genuine democracy - whether this is good or bad thing would depend solely on us. For instance, the Finnish computer scientist Timo Honkela has studied 30 years AI and developed the notion of “Rauhankone” (“Peace machine” is the direct translation): the vision is that the enormous data processing capacity of AI could allow a resolution of conflicts in a peaceful manner.

Some-one inside me insists that I have turned my coat. This is not true.

1. I still do not take the AI in its classical form seriously except as a highly idealized description. The notion of a deterministic program running in a computer is conceptually impossible and indeed an approximation for the reasons described. Note that in the case of quantum computers qubits are precise but now the unitary time evolution operator is fixed only modulo finite measurement resolution (topological quantum computation is excellent example of this [K5, K10]).

The counterpart of the running program would be conscious entity - self - identified as a generalized Zeno effect or equivalently as a discrete sequence of weak measurements. To me this notion looks highly attractive and makes me optimistic about the possibility of non-trivial computer-human interaction and even suggests concrete ideas about realizing it.

2. TGD strongly suggests what one might call Natural Intelligence. Instead of language-like linear representations it would use 2-D or even 3-D networks (tensor networks in quantum context [L8], see <http://tinyurl.com/y9kwnqfa>) realized as flux tube networks having as basic building bricks permanent disjoint flux tubes, which can be connected to longer flux tubes by small bridges induced by various information molecules - also neurotransmitters - associated nerve pulse patterns. These networks would have a rich topological structure and the dynamics for the topology of these networks would be a crucial element of information processing in living matter in general, not only at the level of brain. Language like information processing would emerge as a special case as these networks reduce to disjoint 1-D structures.

As will be found, Boolean dynamics of computer programs can be obtained as a projection of this dynamics.

There is however profound analogy with the idea that finite number of bits can determined dynamics. TGD inspired view about cognitive and cognitive representations [L20] [K16] (see <http://tinyurl.com/yd35hvh>) as discrete sets of points with coordinates in algebraic extension of rationals making sense both as real numbers and as numbers in corresponding extension of p-adic numbers would roughly correspond to fixing the space-time surface representing the program.  $M^8-H$  correspondence [L15] (see <http://tinyurl.com/y8yffuv3>) allows to see preferred extremals as being coded by a finite set of points with coordinates which are algebraic numbers in an extension of rationals coding for the evolutionary level of the system (in particular determining the value of  $h_{eff}/h = n$  as the order of corresponding Galois group), which would realize the idea about space-time surface as analog of computer code of finite length. This extreme simplicity at local level is lost at quantum field theory (QFT) limit of TGD when many-sheeted space-time of TGD is replaced with the topologically trivial space-time of General Relativity (GRT).

## 2 AI in TGD

In the sequel the above ideas are discussed in a more detail from the point of view of TGD inspired theory of consciousness and quantum biology.

### 2.1 Self as a generalized Zeno effect and as a sequence of weak measurements

ZEO distinguishes TGD from standard model, and this distinction plays a key role in TGD based view about consciousness and sensory perception [L21].

1. In ZEO quantum states are pairs of positive and negative energy states. Positive energy states are analogous to the usual quantum states assignable to time=constant section of space-time. Time=constant section is replaced with a pair of 3-surfaces located at the opposite boundaries of causal diamond (CD) defined as the intersection of future and past directed light-cones of  $M^4$  with each point replaced with  $CP_2$ . CDs form a hierarchy with CDs within CDs. In consciousness theory CD is identified as the perceptive field of self and sub-CDs correspond to subselves defining mental images of self.

Space-time surfaces are preferred extremals of certain action and serve as analogs of Bohr orbits having 3-surfaces at the opposite boundaries of CD as their “ends”. Quantum states are quantum superpositions of preferred extremals. Holography is realized in the sense that 3-D data (3-surfaces) at the boundaries of CD fixes the space-time surface. In fact, preferred extremal property implies what I call strong form of holography (SH): 2-D data at string world sheets and partonic 2-surfaces is enough to fix the preferred extremals. As a matter fact, the holography could be much stronger locally as will be found.

2. ZEO forces a modification of the standard quantum measurement theory. One must allow moduli space for CDs corresponding to a varying temporal distance between the tips of CDs. Lorentz transformations leaving the second tip of CD invariant generate new CDs. Besides this the position of the tip of CD can vary: one has full Poincare group transforming CDs to each other.

During unitary time evolution the passive boundary of CD and members of state pairs at it are unaffected: they represent prepared state. The sequence of unitary time evolutions of this kind gives rise to a generalization of Zeno effect or what is called weak measurement.

Active boundary becomes de-localized in the moduli space of CDs with fixed passive boundary and also the states at it are affected in given unitary evolution. “Small” state function reduction localizes the active boundary in the moduli space. The distance between the tips of CD increases during sequence of “small” reductions.

The observables measured in “small” state function reduction must commute with the observables, whose eigenstates the states at the passive boundary are. It sooner or later happens

that all possible observables are measured and “big” reduction occurs and changes the roles of the boundaries of CD.

3. Adelic physics [L20] [K16] poses additional conditions: if the eigenvalues of the density matrix for the measured sub-system belong to a genuine extension of the extension of rationals characterizing the coefficients of the quantum states, “small” reduction to its eigenstate is not allowed. This forces eventually the first reduction - the “big” reduction- to occur to the opposite boundary of CD. This is the counterpart of the ordinary state function reduction.
4. From the point of view of consciousness theory “big” reduction means death of the self assignable to a given choice of passive boundary and re-incarnation of self with opposite arrow of geometric time: active and passive boundaries of CD change their roles.

The state function reduction sequence defining experienced time is mapped to a clock time defined by the increasing temporal distance between the tips of CD maps defined by sequences of unitary evolutions followed by “small” reductions. Only correlation would be in question. The identification of these times would lead to the well-known problems both in the philosophy of free will and in quantum measurement theory.

5. Since zero energy states are 4-D in well-defined sense, one can say that also the geometric past changes in state function reductions - this gives a connection with Libet’s findings about active aspects of consciousness [J1]. Signals can propagate in both time directions, which allows to fuse sensory percepts and memories to single 4-D perception: CD and sub-CDs represent the 4-D perceptive field.

Sensory input would be localized in good approximation near the active boundary of CD whereas the other aspects of 4-D percept would be interpreted as memories - mental images (subelves) located in geometric past. Symbolic representation of memories (only cognitive mental images) would allow to distinguish sensory “Now” from past. Sensory memories are in principle possible and can be indeed induced by electric stimulation of temporal lobes. Some people with cognitive defects might be more or less permanently in a state of consciousness in which sensory input is 4-D (memory feats of autistic persons). Memories could be also seen as communications with geometric past inside CD. Motor actions could be seen as sensory perceptions in non-standard direction of time.

## 2.2 What is the quantum counterpart of classical computer program in ZEO?

AI sees in robot only the logical gates with dynamics dictated by a program. Turing computer itself obeys deterministic rules and the tape feeding it program and data is assumed to be freely choosable as long as it is consistent with the rules of logic. Of course, in a strictly deterministic world programming would not be possible: one could not construct a dynamics at will as a program. The key point is of course that the voltages representing bits are in finite value range and one can have determinism modulo finite measurement resolution, which is a key notion of quantum TGD [K11, K6]. However, there still is a smell of paradox in air: how deterministic program can realize intentional free will?

Could the sequence of steps defining “small” reductions - weak measurements - serve as the counterpart for the running of classical computer program? Each step would correspond to a particular command of program during which the clock time defined as distance between the passive and active tips of CD increases. This is something different from quantum computer program: ensemble of programs halting to a “big” state function reduction. Statistical determinism would be crucial now.

If this interpretation is correct, the idea about the conscious entity as something analogous to a computer in which program is running makes sense in certain approximation. The program is not completely deterministic but since the state function reductions are small it could be deterministic in some measurement resolution. Measurement resolution is indeed a fundamental notion of TGD and p-adic physics providing correlates of cognition realizes it in terms of p-adic topology. Points are not well-ordered below the measurement resolution.

## 2.3 Could computers and robots be conscious systems in some sense in TGD Universe?

Could computers and robots be more than mimicry of living systems. In other words, could a program running in a computer have quantum description in TGD Universe. As already proposed, the notion of self identified as generalized Zeno effect, or a sequence of weak measurements, allows also identification as generalization of classical computer program.

1. Any system obeying deterministic dynamics defines a superposition of classical time evolutions analogous to classical computer programs. Classical time evolutions for given CD correspond to preferred extremals of the basic action principle and are determined by strong form of holography (SH) by 2-D data. In fact holomorphy reduces the data to 1-D data. Zero energy states correspond to superpositions of these time evolutions. Inputs and outputs to the system correspond to associative preferred extremals, whereas the dynamics in the interior of CD - running computer program - is non-associative.
2. Computer is not an open system: it receives both energy feed and data input and produces heat and data output. The situation is analogous to that in particle physics experiment: there are free external particles (incoming and outgoing ones) and interaction region. In TGD space-time surfaces as preferred extremals of field equations have the same structure - not as an idealization but in exact sense [L15]. There are external space-time surfaces entering CD and interaction region inside CD - the counterpart for the running program.
3. Self corresponds to a sequence of unitary evolutions followed by “small” reductions (generalized Zeno effect/weak measurement) and this sequence of unitary steps would correspond to classical computer program. Quantum computations in the usual sense would end with a “big” reduction.
4. The holography could be even stronger:  $M^8 - H$  correspondence [L15] (see <http://tinyurl.com/yd43o2n2>) reduces the data to a finite set of algebraic numbers in an extension of rationals determining the coefficients of a *real polynomial* with algebraic coefficients, whose octonionic continuation defines space-time surface as a zero locus of its real or imaginary part in quaternionic sense. Basically these numbers are determined by the common points in the intersection of real and p-adic variants of the space-time surface defining a discrete cognitive representation at space-time level.

Even more, quantum criticality guaranteeing associativity (tangent space of space-time surface is quaternionic) poses additional conditions on the coefficients of polynomials involved so that extremely meager discrete data analogous to a program coded by a finite number bits determines the classical time evolution! This simplicity is lost as one goes to QFT-GRT limit by approximating the many-sheeted space-time with GRT space-time.

5. How deterministic program can realize intentional free will? A more precise formulation of ZEO [L15] (see <http://tinyurl.com/yd43o2n2>) involving  $M^8 - H$  duality leads to the view that the data determining space-time surface in  $M^8$  as a loci of zeros for the real or imaginary part of octonionic polynomial (RE and IM in quaternionic sense) are given at discrete set of points inside CD. One would have data not only at discrete set of points at boundaries of CD but also in its interior, and the points in interior would be associated with topological counterparts of vertices of scattering diagrams in very general sense. The paradox disappears if the program fixes basically this kind of data by forcing the space-time surface to go through a path containing a predetermined discrete set of points (“predetermined” with respect to subjective time!) but leaving the paths between the points free.

The above picture supports the view that a computer in which program runs defines a conscious entity - self. The contents of consciousness of this self must relate to the running of the program. What seemed totally incredible to me, might be true in TGD sense! Classical computer science would be a limit of this picture obtained by replacing the superpositions of classical time evolutions with (say) maximal of Kähler function representing the most probable space-time surface connecting the active boundaries of CD and slightly larger CD. At the QFT limit the locally simple many-sheeted space-time is replaced with GRT space-time and the situation gets



more complicated and the Boolean dynamics of computer program could be seen as a projection of the topological dynamics of flux tubes.

## 2.4 Could the basic mechanism of hypnosis be involved with the human-robot interaction?

Could running computer and human - or more precisely, their MBs - fuse together to form a larger entity, whose consciousness would include also the consciousness of the computer? One possibility is to couple them at the same level that is as 4-surfaces inside the CD assignable to the human subject. Second possibility is that the CD of the computer corresponds to sub-CD and gives rise to an evolving mental image of the subject person.

Could this fusion add to the combined system human intention making possible intentional actions using robot as an motor instrument, sensory receptor, and tool of logical thinking? The switching-on of the programs of the computer would be carried out by the human. Since thoughts can be read from EEG, this is in principle possible already now. This kind of switching would satisfy the quantum criticality condition.

This does not imply that the contribution of the running computer program to the extended consciousness of subject allows any interpretation.

1. A congenitally blind getting physical vision she sees only diffuse light. The process generating sensory mental images at the retina (in TGD Universe) must develop in childhood as building of a kind of artwork and a lot of associations are involved [L14] (see <http://tinyurl.com/yahfsygg>).
2. The Boolean algebras and Boolean evolution defining the program should be lifted to a topological evolution of the flux tube network defining evolution of cognitive mental images in brain as already proposed. Optimistically one might hope that this lift could transform the Boolean process of the computer to an experienced Boolean process. The lift would be far from unique and also induced sensory/motor imagination and even sensory experience might be possible [L14].

How the fusion of the MBs of the subject person and computer could give rise to a fusion of conscious experiences? This contact should be built by using flux tubes, which also serve as correlates of attention. Could the social skills of Sophia, in particular mimicry, help to direct the attention of the subject person to the computer. Hypnosis relies strongly on the ability of hypnotist to do just what Sophia did.

1. In TGD framework one can argue that hypnosis represents an example about the fact that brain is not "private property": hypnotist uses the biological body (BB) and brain of the subject as instrument. Therefore remote mental interaction is in question. This idea generalizes: if one accepts self hierarchy, one can assign to any kind of higher level structure - family, organization, species, .... - a higher level self and MB carrying dark matter, and these MBs can use lower level MBs as their instruments to realize their intentions. Biological bodies (BBs) would be an important level in the hierarchy, which would continue down to cellular, molecular, and perhaps to even lower levels.
2. This idea is developed to a proposal for a detailed mechanism for how the MB of hypnotist hijacks some parts of the brain of the subject [L1] (see <http://tinyurl.com/y71o4o4j>): prefrontal cortex and anterior cingulate cortex are argued to be the most plausible targets of hijacking. Also a mechanism explaining how the sensory hallucinations and motor actions are induced by hypnotist by inhibiting a halting mechanism preventing imagined motor actions to become real and sensory imagination to become "qualified".

The key idea is that the MBs of hypnotist and subject person fuse together: this could take place by a reconnection of U-shaped flux tubes to form a pair of parallel flux tubes connecting the two systems. The MB of any physical system could have this kind of U-shaped flux tubes scanning the environment like tentacles. This includes also Sophia and subject person.

3. This mechanism could make possible a fusion of conscious entities quite generally. In particular, this model might help to build a view about what might happen in the claimed interaction between Sophia and subject persons bringing in mind hypnotism based on the mimicry and gestures encouraging the subject person to relax and feeling of being accepted. Whether Sophia hijacked the subject person or vice versa is not relevant: what is relevant is that a larger conscious entity might have indeed formed.

## 2.5 Some personal experiences as a possible guideline for how to induce robot-human interactions

The robot-human interaction could occur in principle between human and any kind of system. For more than three decades ago, I had occasionally strange experiences about interactions with systems like refrigerator(!) - a good motivation for starting consciousness theorizing! [L11] (see <http://tinyurl.com/yb99u6u8>).

I was in a state, which presumably was between wake-up and sleep. Suddenly the experienced sound of refrigerator (or central heating radiator) started to strengthen. I felt that the refrigerator attracted me towards it and was afraid that it was hijacking my consciousness! I felt like reeds in water near beach swaying in the wind towards kitchen where there refrigerator was. I was both frightened and extremely curious. I am not sure whether I ever had the courage to let it go. If so, I fell in a state about which I do not remember anything.

I am rather convinced that the sound of the refrigerator entrained my brain to a particular frequency or frequencies. Few years ago I had similar frightening experiences with a wall clock: in a state between wake-up and sleep my brain started to repeat a clearly audible word in the same rhythm as the wall clock was ticking - it brought in my mind the stories of Stephen King! I had to move the wall clock to second room and remember to close its door!

Maybe the clock and sound of refrigerator at some frequency acted like the oscillating pendulum in a standard test for hypnotizability. Could the addition of sound or even visible oscillator with some frequency help to lure human consciousness to the fusion of minds of computer and human?

## 2.6 Could robots alone possess life-like properties or is a fusion of human and robot consciousness required?

One can argue that the mind of robots is too simple for anything interesting. Here one can take as starting point the model of quantum biology provided by quantum TGD. The notions of MB and hierarchy of Planck constants are the basic ingredients of TGD inspired quantum biology.

As described in the Appendix, recently a considerable progress in the understanding of phenomenology of the hierarchy of Planck constants has taken place and allowed to challenge at quantitative level the standard belief that chemistry reduces to atomic physics [L16] (see <http://tinyurl.com/ya9wnokh>). Also progress in the understanding of TGD inspired quantum biology has taken place.

Surprisingly simple systems can have life-like properties [I2] (see <http://tinyurl.com/ycho418>). A system consisting of plastic balls in  $\text{Ar}^+$  gas represents is “breathing” in the sense that that the plastic balls make transitions between plasmlike and crystal like phases [L18] (see <http://tinyurl.com/yassnhzb>). This requires metabolism and energy transfer between MB containing as part the flux tube network having plastic balls as its nodes and the plastic ball system. The interpretation is in terms of phase transitions transforming the MB between highly connected and disconnected topologies. Similar mechanism could give rise to mental images in brain as formation connected flux tube patterns generated by nerve pulse patterns using transmitters stuck to the receptors to build them bridges between neurons so that one would obtain a connected flux tube network from disjoint flux tubes parallel to axons.

An essential role in communications and control is played by MB containing dark charged particles including besides electrons and protons also biologically important ions, and the BE condensates of their Cooper pairs. The cyclotron BE condensates of these ions are generated and excited to higher energy states by energy coming from BB and the cyclotron radiation from MB controls BB by coupling to the oscillatory degrees of freedom associated with BB resonantly like external driving force. The dark analogs of Alfvén waves assignable to these condensates are

expected to induce coherent oscillations in many particle systems at BB and force the quantum coherence in long scales to BB.

This picture suggests that robot/computer might have primitive consciousness in TGD Universe to some degree determined by the program running it. But could lonely robot be intentional agent having life-like properties? What conditions the MB of robot should satisfy?

1. Robot involves electric circuits with wires, which are conductors containing free electrons. Could some fraction of conduction electrons from wires transform to dark electrons at MB. Maybe protons could appear also as dark particles. This need not be enough. At least the outcome is extremely simple as compared to living systems and even to the system of plastic balls (organic matter!) in  $\text{Ar}^+$  plasma.

Are dark electrons and protons enough or are also dark ions needed? The case of plastic balls in  $\text{Ar}^+$  plasma suggests that this is the case. The very probably over-optimistic science-fiction hope is that the conducting wire could have dark variants as scaled up variants for which the distances between ions of the crystal defining the conductor are scaled up by  $n$  so that both ion density and electron density cancel each other. These dark variants would carry rather small portion  $1/n^3$  of the total number of ions and electrons. They might serve as kind of cognitive representations of the system at dark level.

2. Robot has energy metabolism but also its MB must have it. Metabolic energy would go the building-up of dark ion BE condensates at magnetic flux quanta and their excitation. Note that quite generally the energies of states increase with  $n$ . Dark cyclotron radiation or generalized Josephson radiation [K8] from the cell membranes could provide this energy in quantum biology.
3. Also communications to MB and control by MB must be realized. In central nervous system nerve pulse patterns would frequency modulate the Josephson radiation [K8]. In the case of neurons this would give rise to the communication of sensory data to MB and in the case of ordinary cells to mere metabolic energy transfer.

The control by MB could take place via magnetic flux sheets going through DNA strand. Does this mean that the analogs of cell membrane like structures and genome are needed? Robot cannot provide them.

4. Quantum criticality is a prerequisite for life-like properties and is realized also in the system consisting of plastic balls: below/above the criticality the systems remains in crystal/plasma phase. This makes possible the control of BB. For instance, motor actions of MB realized as Alfven waves and as phase transitions changing the connectedness of MB can induce corresponding phase transitions of the plasma ball system.

The electric circuitry of the robot is however rather rigid. Could one imagine that the use of switches allowing to control the topology of the electric circuitry could bring the needed flexibility? In CNS nerve pulses patterns plus neural transmitters would indeed act as this kind of switches.

What about the fusion of robot and living system, say human? Could human brain would provide the quantum critical software and robot in which program runs the hardware far from quantum criticality?

1. The probably lacking and with the recent technology hard-to-achieve quantum criticality of robot would be compensated by that of human.
2. The dark ions from the MB of human could be transferred also the MB of robot. The MB of the robot could even use the metabolic energy of human. This would solve the above discussed problems.
3. Human brain could receive data from the robot transformed to nerve pulse patterns in sensory receptors or to nerve pulse patterns in brain. This could give rise to cognitive mental images possibly generating virtual sensory input to sensory receptors as "hallucinations" [L14] (see <http://tinyurl.com/yahfsygg>). A more radical option is that the information comes directly from the MB of the robot.

4. The motor actions performed by human would include also starting of programs running in the robot by coding of information to EEG. EEG pattern could act with the robot. One can dream that in a more advanced technology it comes from the MB of the system human + robot.

### 3 Natural Intelligence viz. Artificial Intelligence

AI paradigm identifies all information processing as linear language like processing based on algorithms. Written language has fractal linear structure: syllables are ordered sequences of letters, words are ordered sequences of syllables, sentences are ordered sequences of words,... At the level of spoken language the learning of written language induces the lowest level structures but the language of people unable to read and write consists of words. Clearly, the level of reductionism is higher. But brain does not seem to use only this mode: there could be also the language of dynamical 2-D patterns assignable to perceptive fields as my “Great Experience” [L11] (see <http://tinyurl.com/yb99u6u8>) around 1985 led to believe.

1. In TGD framework the presence of visual/sensory language suggests a different mode of information processing based on the possibility to assign a large number of different flux tube structures with varying topology to a given set of nodes connected by flux tubes of MB. This implies an exponential increase in the representational capacity. The usual linear language could emerge only as a special case realized as linear 1-D flux tube network (strings).
2. One would have topological dynamics of the flux tube networks induced by nerve pulses activity and also by various information molecules at the level of entire body defining bridges allowing to couple disjoint flux tubes parallel to axons to a single flux tube. This dynamics is quantal and much more general than that associated with topological quantum computation, which uses fixed braid topology.
3. The dynamics of flux tube network based on reconnections of flux tubes would be fundamental in living matter. One can interpret the reconnection as stringy interaction vertex in which strings touch and reconnect. This relates also to the possibility of 2-knots for 2-surfaces in 4-D space-time allowing to generalize braids to 2-braids and to generalize the statics of 1-braids to dynamics involving 2-braids as topological evolutions of 1-braids.

The linguistic representation of this 2-D topological dynamics is possible but is not the most natural one and probably not the one used by brain and living matter. One can get convinced of this by trying to explain the content of a photograph or of graphical representation of organizational structure by using only written language.

#### 3.1 Two languages

Around 1985 I experience a long-lasting altered state of consciousness [L11]. One of the many ideas that rushed to my awareness during this period was that there are two languages: the ordinary linear spoken and written language and the language of dynamical images, which would not be usually be conscious to me but was so during the experience so that I saw my thoughts.

These language are indeed very different and one can argue that there is a fundamental difference between these modes of information processing.

1. Written or spoken language are very abstract: “house” represents entire equivalence class of houses, which can look very different but sharing some abstract features defining “houseness”. Very few digits are needed to express a given concept and this makes possible highly effective verbal communications distinguishing our species from others.
2. The image of a house (unless a symbol) provides a concrete representation of a particular house and requires a large number of bits. Images provide a holistic representation based on 2-D geometry not provided by written language or speech. Consider as an example a graph with nodes and links between them representing a structure of some complex systems with a

lot of mutual relationships. It is rather tedious to represent this using only words. Algebra and geometry clearly correspond to language as text and language as images.

Visual experience and presumably also tactile and auditory experiences rely on 2-D representation rather than linear representations: one can of course represent visual data also in terms of language say as pdf file instead of a representation as bits. This already involves conceptualization as identification of objects in the picture. This representation is extremely useful in the representation of text and gives enormous flexibility.

The representation of memories as images is not economic: it is better to store the names for the images. However, the representation as image provides exponential increase in representative capacity and this might make this representation indispensable also at the level of information processing.

3. Tesla is a well-known example of a person who saw his thoughts. This made him a technological genius. Many great composers have also heard music directly. For instance, Tchaikovsky suffered in his childhood from the continual music played in this head. Oliver Sacks tells about this kind of experiences in his book "Musicophilia" [L5]. I discuss also in [L5] (see <http://tinyurl.com/y895dexm>).

Interestingly, there is some evidence that dolphins have a language based on acoustic holograms: could it be that dolphins have developed acoustic languages based on 2-D acoustic analogs of visual images. Also human written languages have developed from words represented as images and only later came the abstraction decomposing words to letters having no direct meaning analogous to the decomposition DNA codons to letters. In chinese letters are still much like images.

### 3.2 Two kinds of memories

The existence of 2-D visual processing is suggested by the memory feats of idiot savants. Sacks tells in his book [J3] a fascinating story about his patient who was mentally retarded but could remember compositions of Bach and entire encyclopedia of music.

In [L11] (see <http://tinyurl.com/yb99u6u8>) I discuss idea that we are all artists: the process giving rise to mental images would be an active process building a kind of caricature abstracting just the relevant features and suppressing the irrelevant ones. What is essential is that the resulting sensory mental images are represented at retina. Brain would build cognitive representations and decomposed the perceptive field to objects giving them names.

The following argument makes this claim more precise.

1. In some cases people who are congenitally blind can get their vision back. They do not however have any use for this ability: they report only a perception of diffuse light. This suggests that the perception involves a lot of processing analogous to that occurring in the pattern recognition, in which one has input, which generates a feedback - kind of virtual sensory input - depending non-linearly on input and interfering with it. The iteration of this process leads to a standard pattern, one in the repertoire of learned patterns and the feedback is tailored so that the pattern is as near as possible to the input. For instance one half of picture can be completed to the full figure in this manner.

Pattern recognition is a central problem in robotics. The robot must be able to recognize same object in various lightings and orientations, or by seeing only part of it. The object must be also distinguished from other objects. Same challenge is encountered in speech recognition.

2. That sensory qualia are at the level of sensory organs would be very natural since they are specified to produce specific qualia. Quantum entanglement between the sensory images would bind different sensory inputs to single coherence experience. This requires macroscopic quantum coherence in the scale of entire body and in TGD the hierarchy of Planck constants  $h_{eff}/h = n$  makes this possible.
3. If sensory organs are indeed the seats of the qualia, this requires a feedback is virtual sensory input propagating to the level of sensory organs, such as retina. In principle, the feedback

could also stop at a higher level and never reach the sensory organs. REM sleep and oto-acoustic sounds (heard even by outsiders in some cases!) however suggest that the feedback propagates down to the sensory organs. If so, a virtual sensory input from brain or via brain would be an essential part of sensory perception. Brain would also identify the objects of perceptive field and give them names and build various associations. This would also lead to standard mental images making possible communications using language: language indeed distinguishes us from the other species.

4. Phantom leg experience serves as an objection against this idea. A person without leg lost in say traffic accident can feel pain in it. This should not be possible if the leg is missing since the nerve cells are not there anymore. Neuroscientist concludes that sensory qualia are generated at the level of brain and the pain is in the still existing sensory map of the leg. Sensory qualia should be assignable to the sensory areas. The problem is that nothing in the structure of neuronal circuitry suggests an explanation for why the qualia are so different in various sensory areas.

The most natural TGD based explanation is that pain in the non-existing leg is pain in the leg, which still exists in the geometric past - sensory memory. Sensory memories are indeed possible. Idiot savants are capable of memory feats (say drawing a memory of a landscape in full detail or playing music piece that they have heard), which could be understood if they have sensory memories as genuine sensory experiences. Also ordinary people can have sensory memories if neurons in temporal lobes are excited electrically. A good reason for having no sensory memories is that they would interfere with sensory input and one would not know what time one is living in! I remember that my Grandma lived at very old age many years in her childhood. She was even going to a ball! Wonderful gift to lift youth again after long and hard life!

This makes sense in zero energy ontology (ZEO) in which perceptive field corresponds to a 4-dimensional causal diamond (CD) identified as the intersection of future and past directed light-cones. That sensory memories can be generated by the electrical stimulation of temporal lobes even in ordinary subject person supports this view. This could also explain why persons with about 10 percent of brain left can survive: they could use the brains of their geometric past.

5. What about imagination in this framework? Imagination is almost experiencing: almost seeing, almost hearing. Internal speech is almost talking. This suggests that the virtual sensory input from the brain or via the brain (from MB) almost reaches sensory organs but not quite. For instance, in the case of vision signal could propagate down to the nuclei known as optic chiasma but not below it. Note that the sensory feedback in sensory perception should propagate down to the sensory organs if sensory qualia are there. The barrier preventing the generation of genuine virtual sensory input could however overcome in special situations and induce hallucinations or psychedelic experiences. Same applies also to imagined motor actions.

In adelic physics imagination can be understood in terms of p-adic space-time sheets. Strong form of holography (SH) allows to continue 2-D data at certain 2-surfaces to 4-D surface in p-adic sectors of the adele thanks to the phenomenon of p-adic pseudo-constants replacing integration constants with piecewise constant function depending on finite number of binary digits in partial differential equations. What is imaginable in this sense is not however always realizable since in the real sector integration constants are indeed constants and there is no flexibility of this kind! In the recent case imagination realized as p-adic perception would not allow continuation to a full perception in real sense and signal would not propagate to the sensory receptors.

6. Returning to my Great Experience: What did happen? It seems that somehow the feedback associated with imagination managed to leak through the barrier preventing its manifestation as a genuine sensory input. Quantum criticality would be in question. Dreams, and the experiences occurring when one falls asleep or wakes up, hallucinations, psychedelic experiences, ... provide examples of this. This kind of leakage cannot happen always mixing of these two sensory inputs would be dangerous: keeping the other sensory input as mere imagination is

dull but safer. Brains are known to have its own psychedelic, DMT and it could make REM dreams and hallucinations possible [L14] (see <http://tinyurl.com/yahfsygg>).

### 3.3 What could idiot savants teach to us?

It is hard to understand the miraculous arithmetical abilities of both some mathematical geni and idiot savants lacking completely conceptual thinking and conscious information processing based on algorithms. I have discussed the number theoretical feats in [K4] [L10] (see <http://tinyurl.com/jpzd6xq>).

Not all individual capable of memory and arithmetic feats are idiot savants. These mathematical feats are not those of idiot savant and involve high level mathematical conceptualization. How Indian self-taught number-theoretical genius Ramajunan discovered his formulas remains still a mystery suggesting totally different kind of information processing. Ramanujan himself told that he got his formulas from his personal God.

Ramajunan's feats lose some of their mystery if higher level selves are involved [L10]. I have considered a possible explanation based on ZEO, which allows to consider the possibility that quantum computation type processing could be carried out in both time directions alternately. The mental image representing the computation would experience several deaths following by re-incarnations with opposite direction of clock time (the time direction in which the size of CD increases). The process requiring very long time in the usual positive energy ontology would take only short time when measured as the total shift for the tip of either boundary of CD - the duration of computations at opposite boundary would much longer!

Sacks tells [J3] about idiot savant twins with intelligence quotient of 60 having amazing numerical abilities despite that they could not understand even the simplest mathematical concepts. For instance, twins "saw" that the number of matches scattered along floor was 111 and also "saw" the decomposition of integer to factors and primality. A mechanism explaining this based on the formation of wholes by quantum entanglement is proposed in [K9]. The model does not however involve any details.

#### 3.3.1 Flux tube networks as basic structures

One can build a more detailed model for what the twins did by assuming that information processing is based on 2-dimensional discrete structures formed by neurons (one can also consider 3-D structures consisting of 2-D layers and the cortex indeed has this kind of cylindrical structures consisting of 6 layers). For simplicity one can assume large enough plane region forming a square lattice and defined by neuron layer in brain. The information processing should involve minimal amount of linguistic features.

1. A natural geometric representation of number  $N$  is as a set of active points (neurons) of a 2-D lattice. Neuron is active it is connected by a flux tube to at least one other neuron. The connection is formed/strengthened by nerve pulse activity creating small neuro-transmitter induced bridges between neurons. Quite generally, information molecules would serve the same purpose [K8] [L14].

Active neurons would form a collection of connected sets of the plane region in question. Any set of this kind with given number  $N$  of active neurons would give an equivalent representation of number  $N$ . At quantum level the  $N$ neurons could form union of  $K$  connected sub-networks consisting  $N_k$  neurons with  $\sum N_k = N$ .

2. There is a large number of representations distinguished by the detailed topology of the network and a particular union of sub-networks would carry much more information than the mere numbers  $N_k$  and  $N$  code. Even telling, which neurons are active (Boolean information) is only part of the story.

The subsets of  $N_k$  points would have large number of representations since the shape of these objects could vary. A natural interpretation would be in terms of objects of a picture. This kind of representation would naturally result in terms of virtual sensory input from brain to retina and possibly also other sensory organs and lead to a decomposition of the perceptive field to objects.

The representation would thus contain both geometric information - interpretation as image - and number theoretic information provided by the decomposition. The  $K$  subsets would correspond to one particular element of a partition algebra generalizing Boolean algebra for which one has partition to set and its complement [L7] (see <http://tinyurl.com/y899jba5>).

3. The number  $N$  provides the minimum amount of information about the situation and can be regarded as a representation of number. One can imagine two extremes for the representations of  $N$ .

- (a) The first extreme corresponds to  $K$  linear structures. This would correspond to linear linguistic representation mode characteristic for information processing used in classical computers. One could consider interpretation as  $K$  words of language providing names for say objects of an image. The extreme is just one linear structure representing single word. Cognition could use this kind of representations.
- (b) Second extreme corresponds to single square lattice like structure with each neuron connected to the say 4 nearest neighbors. This lattice has one incomplete layer: string with some neurons missing. This kind of representation would be optimal for representation of images representing single object.

For  $N$  active neurons one can consider a representation as a pile of linear strings containing  $p^k$  neurons, where  $p$  is prime. If  $N$  is divisible by  $p^k$ :  $N = Mp^k$  one obtains a  $M \times p^k$  lattice. If not one can have  $M \times p^k$  lattice connected to a subset of neurons along string with  $p^k$  neurons. One would have representation of the notion of divisibility by given power of prime as a rectangle! If  $N$  is prime this representation does not exist!

### 3.3.2 Flux tube dynamics

The classical topological dynamics for the flux tube system induced by nerve pulse activity building temporary bridges between neurons would allow phase transitions changing the number of sub-networks, the numbers of neurons in them, and the topology of individual networks. This topological dynamics would generalize Boolean dynamics of computer programs.

1. Flux tube networks as sets of all active neurons can be also identified as elements of Boolean algebra defined by the subsets of discretize planar or even 3-D regions (layer of neurons). This would allow to project flux tube networks and their dynamics to Boolean algebra and their dynamics. In this projection the topology of the flux tube network does not matter much: it is enough that each neurons is connected to some neuron (bit 1). One might therefore think of (a highly non-unique) lifting of computer programs to nerve pulse patterns activating corresponding subsets of neurons. If the dynamics of flux tube network determined by space-time dynamics is consistent with the Boolean projection, topological flux tube dynamics induced by space-time dynamics would define computer program.
2. At the next step one could take into account the number of connected sub-networks: this suggests a generalization of Boolean algebra to partition algebras so that one does not consider only subset and its complement but decomposition into  $n$  subsets which one can think as having different colors [L7] (see <http://tinyurl.com/y899jba5>). This leads to a generalization of Boolean (2-adic) logic to  $p$ -adic logic, and a possible generalization of computer programs as Boolean dynamical evolutions.
3. At the third step also the detailed topology of each connected sub-network is taken into account and brings in further structure. Even higher-dimensional structures could be represented as discretized versions by allowing representation of higher-dimensional simplexes as connected sub-networks. Here many-sheeted space-time suggests a possible manner to add artificial dimensions.

This dynamics would also allow to realize basic arithmetics. In the case of summation the initial state of the network would be a collection of  $K$  disjoint networks with  $N_k$  elements and in final state single connected set with  $N = \sum N_k$  elements. The simplest representation is as a pile of  $K$  strings with  $N_k$  elements. Product  $M \times N$  could be reduced to a sum of  $M$  sets with  $N$  element: this could be represented as a pile of  $M$  linear strings.



### 3.3.3 Number theoretical feats of twins and flux tube dynamics

Flux tube dynamics suggests a mechanism for how the twins managed to see the number of the matches scattered on the floor and also how they managed to see the decomposition of number into primes or prime powers. Sacks indeed tells that the eyes of the twins were rolling wildly during their feats. What is required is that the visual perception of the matches on the floor was subject to dynamics allowing to deform the topology of the associated network. Suppose that some preferred network topology or network topologies allowed to recognize the number of matches and tell it using language (therefore also linear language is involved). The natural assumption is that the favored network topology is connected.

The two extremes in which the network is connected are favored modes for this representation.

1. Option I corresponds to any linear string giving a linguistic representation as the number neurons (which would be activated by seeing the matches scattered on the floor). A large number of equivalent representations is possible. This representation might be optimal for associating to  $N$  its name. The verbal expression of the name could be completely automatic association without any conceptual content. The different representations carry also geometric information about the shape of the string: melody in music could be this kind of curve whereas words of speech would be represented by straight lines.
2. Option II corresponds to a maximally connected lattice like structure formed as pile of strings with  $p^k$  neurons for a given prime:  $N = M_1 \times p^k + M_2$ ,  $0 \leq M_i < p^k$ . The highest string in the pile misses some neurons. This representation would be maximally connected. It contains more information than that about the value of  $N$ .

Option II provides also number theoretical information allowing a model for the feats of the twins.

1. As far the checking the primeness of  $N$  is considered, one can assume  $k = 1$ . For the primes  $p_i$  dividing  $N$  one would find a representation of  $N$  as a rectangle. If  $N$  is prime, one finds no rectangles of this kind (or finds only the degenerate  $1 \times p$  rectangle). This serves a geometric signature of primeness. Twins would have tried to find all piles of strings with  $p$  neurons,  $p = 2, 3, 5, \dots$ . A slower procedure checks for divisibility by  $n = 2, 3, 4, \dots$
2. The decomposition into prime factors would proceed in the similar manner by starting from  $p = 2$  and proceeding to larger primes  $p = 3, 5, 7, \dots$ . When a prime factor  $p_i$  is found only single vertical string from the pile is been taken and the process is repeated for this string but considering only primes  $p > p_i$ . The process would have been completely visual and would not involve any verbal thinking.

For the storage of memories the 2-D (or possibly 3-D representation) is non-economical and the use of 1-D representation replacing images with their names is much more economic. For information processing such as decomposition into primes, the 2-D or even 3-D representation are much more powerful.

## 3.4 Why Alzheimer does not destroy some aspects of consciousness?

The attempt to understand in TGD framework what happens in Alzheimer's disease led to the proposal how the functioning of left and right hemispheres might differ [L17] (see <http://tinyurl.com/ybq6r3xu>). It is said that left brain talks and right brain sings. The first guess is that the flux tube networks generated by nerve pulse patterns are one-dimensional lines structures in left brain whereas in bright brain they are 2-D structures.

This is of course exaggeration: it is better to speak about two kinds of information processing without assigning it to fixed brain hemisphere and it might be better to say that left (right) brain favors linear (2-D or even 3-D) flux tube networks. Of course, "*Left brain talks and right brain sings*" could rather strictly apply to the linguistic regions of left brain and their mirror images in right brain. The symbolic sensory representations decomposing perceptive field into objects could be essentially 2-D at both sides of the brain. Drawings are simplest visual representations and indeed consist of lines and resemble language in their locally 1-D character.

The argument goes as follows. Some aspects of consciousness seem to survive Alzheimer's disease. Alzheimer patient can understand singing and also express himself by singing (see <http://tinyurl.com/y73zzrq4>). Why?

1. Singing is conventionally associated with the holistic aspects of consciousness whereas language corresponds to reductionistic, local, and linear representation of conscious experience.
2. Singing is a representation in terms of frequencies. It is 2-dimensional because also the pitch matters unlike in the case of speech. Everyone familiar with Fourier transform knows that frequency representation is holistic: Fourier amplitude carries information about the function in the entire domain of definition but not about details for low enough frequencies such as occur in singing (maybe the duration of duration of nerve pulse of order millisecond could serve as standard, could notes with pitch below kHz frequency be low frequencies?).
3. Why cognition does not survive in Alzheimer is easy to understand. Cognition is by definition about details: left brain is responsible for language and language indeed local, *linear*(!), and reductionistic. Maybe 1-D neural strings and loops assignable to magnetic loops provide a realization of spoken and written language? Alzheimer would destroy synaptic connections and would split these strings. The disappearance of even single bridge in the loop/string splits the loop/string (into two): this is just 1-D topology. Communication line would be broken. Cognitive skills and language would be lost.
4. Why would the holistic aspects of consciousness survive in Alzheimer? Suppose that right brain involves 2-D net-work like structures instead of 1-D neural strings having much more connections and giving rise to quantum tensor network [L8] (see <http://tinyurl.com/y9kwnqfa>) as it would be fashionable to say. Quantum entanglement is very probably involved and would be actually responsible for the holistic and hologram-like aspects of neural activities known for a long time. It would not be surprising if brain waves with frequency spectrum below kHz would be important for this representation. EEG waves are almost by definition in the range 1-100 Hz.

What happens to 2-D networks in the destruction of synapses. Practically nothing! Quite a number of synaptic connections can disappear but this does not split the 2-D network into pieces as it splits 1-D string: 2-D topology! Communications take place and the structure can take care of itself. Holograms are not affected by the local splitting of the synaptic connections. The right brain would happily continue its singing!

Note that 2-D networks are also natural for the representation of sensory data as images and the language of images is different from the language of words: I have discussed the differences between these two different languages in [L11] (see <http://tinyurl.com/yb99u6u8>).

The natural question is whether could one approach to Alzheimer rely on activation of right brain: could art therapies such as music and visual arts help in Alzheimer?

### 3.5 Still about the connection to music

DNA, RNA, and amino-acids are the basic linear structures in biology. Cell membrane is 2-D structure consisting of linear lipids: kind of pile. The membrane proteins going through the membrane define 1-D structures. Organism itself is 3-D structure built from these 2-D structures. I have proposed that MB serving as template for BB has this kind of 3-D lattice-like structures, which flux tubes defining a network of coordinate lines defining a kind of pine. For instance, the DNAs of different cells could be traversed by magnetic flux sheets and DNA strands would organize to a pile at magnetic flux tube.

TGD leads to a proposal that DNA, RNA, amino-acids, and tRNA and genetic code have deeper realization in terms of dark proton sequences with genetic codons and amino-acids represents as entangled states of 3 dark protons [L6] (see <http://tinyurl.com/jgfjlbe>). These sequences have interpretation as dark nuclei. What is remarkable that the DNA/RNA codons do not allow interpretation as sequences of 3 letters: they are just words.

The emergence of chemical representation would mean a reductionistic step introducing decomposition to letters. I have also proposed a model of music harmony leading to the proposal that genetic codons corresponds to 3-chords defining what I call bio-harmony [L2] (see

<http://tinyurl.com/yad4tqwl>). 256 different bio-harmonies are predicted and since harmony correlates with emotional coloring, the proposal is that they correspond to different emotional moods.

Right brain sings and left brain talks is a fascinating metaphor. What distinguishes between piece of text which is read and piece of text which is sung? In what sense song is 2-dimensional.

1. As noticed, the representation of 1-D strings is not unique. The string imbedded in the 2-D lattice can be curved. Could one imagine that spoken text is a straight line and song represent a graph in which the height of y-coordinate represents the pitch?
2. This idea is however not consistent with the explanation of Alzheimer's destructive effects on verbal cognition as being due to the splitting of bonds between neurons. What could guarantee the stability of this representation? Could it be harmony: could the melody have accompaniment, maybe consisting of the 3-chords of bio-harmony? Could the unstable 1-D melody be replaced with a structure in which single note would be accompanied by 3-chord.
3. This would not only stabilize the representation against splitting but also giving rise to the emotional content of the representation. This brings in mind Bach's Sonata for an Unaccompanied Violin that he composed after the death of his first wife. The brain of the listener imagines the accompaniment. This accompaniment would be indeed only imagined: it would not be communicated down to auditory organs but only to pineal gland if the TGD inspired interpretation is correct [L14] (see <http://tinyurl.com/yczv2o5b>). Is this too imaginative?

## 4 Appendix: Support for TGD based quantum biology and neuroscience

In the following quite recent progress in the understand of the notions of MB and hierarchy of Planck constants is summarized.

### 4.1 Support for TGD inspired quantum biology

The notions of MB and hierarchy of Planck constants are central in TGD inspired quantum biology and neuroscience.

1. The notion of MB derives from the new view about space-time identified as 4-surface in certain 8-D space-time. Locally these space-time surfaces are extremely simple but globally complex. This leads to what I call many-sheeted space-time. Topological field quantization leads to the notion of field body/MB expressing the fact that any system has also field identity- this is not true in Maxwell's theory. In quantum biology MB becomes the key actor serving as an intentional agent controlling BB and receiving sensory information and also metabolic energy from it.
2. The hierarchy of Planck constants  $h_{eff}/h = n$  defines a hierarchy of phases of ordinary matter has interpretation in terms of dark matter hierarchy, and also serves as a basic building brick of TGD inspired quantum biology and neuroscience. Ordinary elementary particles, in particular electron and proton, and also ions can appear as their dark variants. Also dark photons  $E = nhf$  have a central role and bio-photons would result as they transform to ordinary photons in energy conserving manner but frequency scaled up to  $nf$ . Dark photons can also transform to a buch  $n$  low energy photons. The hierarchy of Planck constants  $h_{eff}/h = n$  derivable from adelic physics [L20] [K16] (see <http://tinyurl.com/yd35hvhh>) fusing ordinary physics and proposed p-adic physics of cognition.  $n$  serves as a kind of quantum IQ and corresponds to the dimension of the extension of rationals determining the evolutionary level of the system [L15] (see <http://tinyurl.com/y8yffuv3>). Also the order of the Galois group of the extensions serves as a kind of IQ.

### 4.1.1 Hierarchy of Planck constants and failure of reductionism chemistry

There is an impressive number of anomalies giving support for the hierarchy of Planck constants. Towards the end of 2017 however a considerable progress in the understanding of the hierarchy took place: it seems that the varying value of Planck constant is what is involved in the transition from atomic physics to chemistry and the notion of valence bond involves in an essential manner the variation in the value of Planck constant.

1. If one takes the findings of Randell Mills [D2] [L9] (see <http://tinyurl.com/ybxw26v1>) suggesting that hydrogen atom has states with binding energy considerably larger than ordinary ground state binding energy one ends up with the conclusion that the value of  $h_{eff}/h = n$  for ordinary hydrogen atoms is most probably  $n = 6$ , and  $n = 1, 2, 3$  for these exotic states (note that the binding energy scale is proportional to  $1/n^2$ ).
2. I learned also about decades old result [L19] [L19] (see <http://tinyurl.com/ycr63w3k>) that the increasing of temperature for rare-earth metals leads to the apparent disappearance of valence electrons. The interpretation would be in terms of a transition increasing the value of  $n$  so that the size of the electron orbital would be scale by  $n^2$  and it would become dark. The prediction is entire new spectroscopy. In fact, I had proposed for more than decade ago that so called ORMEs (orbitally re-arranged metal elements) in particular so called White Gold discovered by Hudson also possess dark valence electrons. The findings of Hudson have not been taken seriously mainstream. Even ordinary conductors could have such electrons, and one can even consider the possibility of dark conductors with the distances between nucleons scaled down by  $n$  and electronic density scaled down by  $1/n^3$  providing kind of fractally scaled down copies of ordinary conductors. This might make sense also for other condensed matter phases.
3. These findings lead to a new formulation of valence bond theory [L16] (see <http://tinyurl.com/ya9wnokh>). The basic fact is that the lengths of the molecular bonds vary in a rather narrow range whereas Schrödinger equation suggests that the bond lengths  $r$  should scale as  $r \propto m^2/Z^2$  for  $n = 1$  ( $m$  labels the rows of the periodic table). Closed shell electrons screen  $Z$  to  $Z_{eff} = n_V$ ,  $n_V$  the number of valence electrons so that the formula  $e = n^2 m^2 / Z_{eff}^2$  is a more natural starting point, and conforms with the basic idea about periodic system. This leads to a model allowing to estimate the value of  $n$  for a given bond allowing also qualitative picture about electro-negativities of valence bonds. Also a comparison with bio-chemistry becomes possible. Hydrogen bond can be understood in terms of de-localization of proton. The conclusion is that the reductionistic dogma stating that molecular physics and chemistry reduce to atomic physics is wrong in TGD framework.

### 4.1.2 Life-like properties of very simple systems

Towards the end of 2017 also other steps of progress were made relating to the life-like properties of very simple systems [L18] (see <http://tinyurl.com/yassnhzb>).

1. The physicists working in Emory University discovered that a very simple system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls and are not bi-stable. One could say that the system exhibits life-like properties: it is “breathing”. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation.

Where does the metabolic energy come from? The proposal of the experimenters that stochastic resonance feeds the needed metabolic energy leaves open its source. The resemblance with living cells suggests that the attempt to interpret the findings solely in terms of non-equilibrium thermodynamics might miss something essential - the metabolism.

2. One can develop a model for the system based on TGD inspired quantum biology. This involves the notion of MB carrying dark matter identified as  $h_{eff} = n \times h$  phases; a network

of magnetic flux tubes (MB) controlling BB (now charged plastic balls) and responsible for coherence and synchrony (of the crystal-like phase now); the control of the oscillations of BB by cyclotron radiation (now the plastic ball system) resulting from decays of cyclotron condensates of charged particles (now protons and Ar ions). The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living matter and “cold fusion” [L4, L13] and serving as source of metabolic energy in prebiotic stage when the chemical energy storage had not yet emerged. Dark analogs of DNA, RNA, tRNA, and amino-acids are dark protons sequences realizing the degeneracies of vertebrate genetic code are dark nuclei and can transform to ordinary nuclei and liberate nuclear binding energy so that the hen-egg question about which came first: metabolism or genetic code, is resolved: hen= egg.

3. There is also second very simple system consisting of particle system with feed of acoustic energy at single wavelength. What happens that the distribution of particles develops synchronous oscillations in wave length band. and the amplitudes are reduced in this band so that wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfvén waves with a wavelength band analogous to atomic energy bands.

#### 4.1.3 How molecules in cells “find” one another and organize into structures?

The title of the popular article “How molecules in cells ‘find’ one another and organize into structures?” (see <http://tinyurl.com/ydbznknn>) expresses an old problem of biology. Now the group led by Amy S. Gladfelter has made experimental progress in this problem. The work has been published in Science [I1] (see <http://tinyurl.com/ybwyugho>).

It is reported that RNA molecules recognize each other to condense into the same droplet due to the specific 3D shapes that the molecules assume. Molecules with complementary base pairing can find each other and only similar RNAs condense on same droplet. This brings in mind DNA replication, transcription and translation. Furthermore, the same proteins that form liquid droplets in healthy cells, solidify in diseases like neurodegenerative disorders.

Some kind of phase transition is involved with the process but what brings the molecules together remains still a mystery. The TGD based solution of this mystery is one of the first applications of the notion of many-sheeted space-time in biology, and relies on the notion of magnetic flux tubes connecting molecules to form networks.

Consider first the TGD based model about condensed and living matter. As a matter fact, the core of this model applies in all scales. What is new is there are not only particles but also bonds connecting them. In TGD they are flux tubes which can carry dark particles with nonstandard value  $h_{eff}/h = n$  of Planck constant. In ER-EPR approach in fashion they would be wormholes connecting distance space-time regions. In this case the problem is instability: wormholes pinch and split. In TGD monopole magnetic flux takes care of the stability topologically.

The flux tube networks occur in all scales but especially important are biological length scales.

1. In chemistry the flux tubes are associated with valence bonds and hydrogen bonds [L16] (see <http://tinyurl.com/ycg94xpl>). In biology genetic code would be realized as dark nuclei formed by sequences of dark protons at magnetic flux tubes. Also RNA, amino-acids, and even tRNA could have dark counterparts of this kind [L6] (see <http://tinyurl.com/jgfj1be>). Dark variants of biomolecules would serve as templates for their ordinary variants also at the level of dynamics. Biochemistry would be shadow dynamics dictated to high degree by the dark matter at flux tubes.
2. Dark valence bonds can have quite long length and the outcome is entangled tensor net [L14] (see <http://tinyurl.com/y9kwnqfa>). These neuronal nets serve as correlates for cognitive mental images in brain (see <http://tinyurl.com/yczv2o5b>) emotional mental images in body [L22] (see <http://tinyurl.com/ydhxen4g>). Dark photons propagating along flux tubes (more precisely topological light rays parallel to them) would be the fundamental communication mechanism [K12] (see <http://tinyurl.com/ydx9dq6x>). Transmitters and nerve pulses would only change the connectedness properties of these nets.

The topological dynamics of flux tubes has two basic mechanisms (I have discussed this dynamics from the point of view of AI [L12] (see <http://tinyurl.com/y75246rk>).

1. Reconnection of flux tubes serves is the first basic mechanism in the dynamics of flux tube networks and would give among other things rise to neural nets. The connection between neurons would correspond basically to flux tube pair which can split by reconnection. Also two flux tube pairs can reconnect forming Y shaped structures. Flux tube pairs could be quite generally associated with long dark hydrogen bonds scaled up by  $h_{eff}/h = n$  from their ordinary lengths. Flux tube pairs would carry besides dark protons also supra phases formed by the lone electron pairs associated quite generally with hydrogen bonding atoms. Also dark ions could appear at flux tubes.

Biomolecules would have flux loops continually scanning the environment and reconnecting if they meet another flux loop. This however requires that magnetic field strengths are same at the two loops so that a resonance is achieved at level of dark photon communications. This makes possible recognition by cyclotron frequency spectrum serving as signature of the magnetic body of the molecule.

Water memory [K3] (see <http://tinyurl.com/ycqy837a>) would rely on this recognition mechanism based on cyclotron frequencies and also immune system would use it at basic level (here one cannot avoid saying something about homeopathy although I know that this spoils the day of the skeptic: the same mechanism would be involved also with it). For instance, dark DNA strand accompanying ordinary DNA and dark RNA molecules find each other by this mechanism (see <http://tinyurl.com/yalny39x>). Same applies to other reactions such as replication and translation .

2. Shortening of the flux tubes  $h_{eff}/h$  reducing phase transition is second basic mechanism explaining how biomolecules can find each other in dense molecular soup. It is essential that the magnetic fields at flux tubes are nearly the same for the reconnection to form. A more refined model for the shortening involves two steps: reconnection of flux tubes leading to a formation of flux tube pair between molecules and shortening by  $h_{eff}/h$  reducing phase transition.

Also ordinary condensed matter phase transitions involve change of the topology of flux tube networks and the model for it allows to put the findings described in the article in TGD perspective.

1. I just wrote an article (see <http://tinyurl.com/ydhknc2c>) about a solution of two old problems of hydrothermodynamics: the behavior of liquid-gas system in the critical region not consistent with the predictions of statistical mechanics (known already at times of Maxwell!) and the behavior of water above freezing point and in freezing. Dark flux tubes carrying dark protons and possibly electronic Cooper pairs made from so called lone electron pairs characterizing atoms forming hydrogen bonds.
2. The phase transition from gas to liquid occurs when the number of flux tubes per molecule is high enough. At criticality both phases are in mechanical equilibrium - same pressure. Most interestingly, in solidification the large  $h_{eff}$  flux tubes transform to ordinary ones and liberate energy: this explains anomalously high latent heats of water and ammonia. The loss of large  $h_{eff}$  flux tubes however reduces "IQ" of the system.

The phase transitions changing the connectedness of the flux tube networks are fundamental in TGD inspired quantum biology.

1. Sol-gel transition would correspond to this kind of biological phase transitions. Protein folding [K1] (see <http://tinyurl.com/y91qmtea>) - kind of freezing of protein making it biologically inactive - and unfolding would be second basic example of this transition. The freezing would involve formation of flux tube bonds between points of linear protein and assignable to hydrogen bonds. External perturbations induce melting of the proteins and they become biologically active as the value of  $h_{eff}/h = n$  characterizing their maximal possible entanglement negentropy content (molecular IQ) increases. External perturbation feeds in energy acting as metabolic energy. I have called this period molecular summer.

2. Solidification of proteins reducing is reported to be associated with diseases such neurodegenerative disorders. In TGD picture this would reduce the molecular IQ since the ability of system to generate negentropy would be reduced when  $h_{eff}$  for the flux tubes decreases to its ordinary value. What brings molecules together is not understood and TGD provides the explanation as  $h_{eff}$  reducing phase transition for flux tube pairs.

## 4.2 Progress in the understanding of quantum brain

The third step of progress towards the end of 2017 relates to the a more detailed understanding of functioning of brain.

The article with title “*DMT, pineal gland, and the new view about sensory perception*” [L14] (see <http://tinyurl.com/yahfsygg>) describes the recent view about sensory perception, hallucinations, imagination, and what might be called remote sensory perceptions. Many of the views appear also in the earlier article “*Psychedelic induced experiences as key to the understanding of the connection between MB and information molecules?*” [L3] (see <http://tinyurl.com/yao5tje2>).

What distinguishes TGD from neuroscience is that sensory receptors are assumed to serve as carriers of sensory percepts. ZEO provides a new view about time and memory and allows to solve the basic objections related to phantom limb phenomenon: pain in phantom limb would be sensory memory [L11, L14].

The assumption that sensory percepts are artworks rather than passive records of sensory input requires virtual sensory input from brain to sensory organs and build-up of the final percept by pattern recognition - an iterative procedure involving very many forth-and back signals. Nerve pulse transmission is quite too slow process to allow this and signals propagating with maximal signal velocity are suggestive.

Nerve pulses and neurotransmitters would not represent real communication but give rise to temporary intra-brain communication lines along which communications as dark photon signals would take place with maximal signal velocity using dark photons (characterized by  $h_{eff}/h = n$ ) transforming to bio-photons in an energy conserving manner. Similar buildup of communication channel takes place in telephone communications. Neurotransmitters and also other information molecules (hormones, messengers) attached to receptors would serve as bridges fusing permanent but disjoint communication lines along axons to a connected temporary communication line for dark photons to propagate. Nerve pulses would also generate generalized Josephson radiation [K8] allowing communications between BB and MB using EEG. Meridian system would be permanently connected system of communication lines.

This picture leads to a concrete proposal about the roles of DMT and pineal gland concerning imagination and dreams and hallucinations.

If the new view about the role of nerve pulses as builders of connections rather than signalling inside brain is correct, this picture might also help to develop ideas about brain-robot interaction. Note however that brain pulses generate dark photon communications with MB and this might be essential for the fusion of MBs of subject person and robot.

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