

# What Music Could Teach about Consciousness?

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February 14, 2018

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### Abstract

Recently I have been reading the book by Oliver Sacks titled “Musicophilia” dealing with various aspects of music experience. Humans as a species indeed have a very special relation to music. But is it really genuine characteristic of human consciousness? One can even ask whether consciousness emerges only in higher species or whether it could be in some form a characteristic of any living or even inanimate system? I am not the only quantum consciousness theorists forced to consider panpsychism in some form. In this framework one can ask whether music like aspects of conscious experience could be universal and only especially highly developed in humans?

In this chapter I restrict the consideration to those stories of *Musicophilia*, which I find of special interest from the point of view of TGD inspired theory of consciousness. The outcome is a more precise formulation for the general TGD inspired vision about brain based on basic ideas of quantum TGD.

Zero Energy Ontology (ZEO) implies a new view about the relation between geometric and experienced time and allowing to generalize quantum measurement theory to a theory of consciousness.

Strong form of holography implies the analog of AdS/CFT duality between 2-D representation of physics based on string world sheets and partonic 2-surfaces and 4-D space-time representations. This duality is not tautology and this inspires the idea that these two representations correspond to two modes for consciousness motivating “Left brain talks, right brain sings” metaphor.

1. Language and music could relate to two dual representations of conscious information - local and holistic, cognitive and sensory. Discretization of function/its Fourier transform as a collection of its values at discrete set values of time/frequencies would correspond local/holistic approximations of function. In principle any conscious entity - self- could utilize these two representational modes at appropriate quantum criticality.
2. The holistic “musical consciousness” is assignable to right brain hemisphere and according to the stories of Sacks seems to be characterized by episodal sensory memories. TGD based view about memories relies on ZEO: the memories would be mental images with sensory input from geometric past, genuine sensory experiences of time reversed sub-selves! This picture simplifies considerably and one can see all memories - sensory, cognitive, or emotional - as analogs of phantom pain, which would be also a sensory memory and even more a genuine sensory experience. It is even possible that our biological bodies are used by two selves: right brain hemisphere sleeps when we are awake and vice versa. Even the experiences of epileptics about having double consciousness could be understood.
3. A more concrete realization of “Left brain talks, right brain sings” metaphor relies on the assumption that “magneto-anatomy” is universal. Only the “magneto-physiology” characterized by the values of  $h_{eff}$  characterizing quantum criticality and defining a kind of intelligence quotient dictating the span of long term memory and planned action varies.

$h_{eff}$  would differ for the magnetic bodies of various brain areas, and the spectrum of  $h_{eff}$  for right and left brain would differ and characterize their specializations. For instance, the value of  $h_{eff}$  would be large (small) for the cognitive areas of left (right) brain and small (large) for some higher sensory areas of right (left) brain. Magnetic bodies form a fractal hierarchy and one can characterize even individual cells and neurons by the value of  $h_{eff}$  associated with them. The spectrum for  $h_{eff}$  allows also to distinguish between members of the same species since it defines the skill profile. This obviously goes far beyond the genetic determinism.

## 1 Introduction

Oliver Sacks have written marvellous books giving an overview about neurology not possible to obtain by reading highly specialized articles dealing with highly special problem and producing some statistical correlations and giving very little for anyone who tries to gain overall view.

These books are gems also for those trying to understand consciousness and allow to learn how much is already understood and how vast the variety of strange findings that should be explained by the theories of consciousness is. Sacks’s books allow also to get idea about the limitations of neuroscience: it is far from clear that all the reported strange findings can be really explained in

the framework of neuroscience. What makes these books so enjoyable is that Sacks communicates his message using stories. It is also heart warming to see Sacks's deep compassion towards his patients and the ability to see them as suffering humans.

Recently I have been reading his book "Musicophilia" [J2] dealing with various aspects of music experience. Humans as a species indeed have a very special relation to music. But is it really genuine characteristic of human consciousness? One can even ask whether consciousness emerges only in higher species or whether it could be in some form a characteristic of any living or even inanimate system? I am not the only quantum consciousness theorists forced to consider panpsychism in some form. In this framework one can ask whether music like aspects of conscious experience could be universal and only especially highly developed in humans?

## 1.1 Can One Do Without Music?

According to Sacks, some writers - for instance Pinker [J3] - claim that we could quite well do without music. Most of us would disagree with Pinker on basis of personal experience.

1. Left brain hemisphere dominates as far as functions of brain understood in the framework of neuroscience are considered. It is true, that brain hemispheres could be fighting for metabolic resources and power just as all other life forms and this could lead to suppression of those functions which left hemisphere can take care of.
2. Musician's brain seems to be unique in the sense that its more democratic than average brain. First of all, neurologist can immediately identify musician's brain by visible changes in its anatomy. Corpus callosum connecting the two hemispheres is unusually thick so that left and right brain hemisphere are in much more democratic relationship than usually. Also planum temporale in the auditory area is asymmetric being bigger at the right side. Most of us cannot do without music. Could it be that behind music is something which is vital element of being conscious?
3. One can argue that the dominance of left hemisphere in adults reflects the fact left brain dominated consciousness is optimal for survival. Cognitive representations are abstractions and require much less bits than sensory representations, which are concrete and extremely detailed. The symbolic character of cognitive representations makes them also much more flexible. To understand what I mean consider the representation of a page of book using bit graphics to that using vector graphics file with letters identified as symbols allowing large number of representation in various fonts and pictures decomposed to basic elements. One might say that cognitive representations are for scientist and sensory representations for artist. But again: we cannot live without art!
4. But why Nature would have built right hemisphere at all if it were useless? Could right brain have hitherto un-identified functions understandable only by widening the scope? EEG has been often often seen as a mere neural noise but it is now known that EEG codes for the contents of consciousness: could it be that EEG relates to the special functions of right hemisphere somehow? It seems useless to code information to EEG if it is not communicated somewhere. Where? And what would distinguish between the EEGs of right and left hemisphere?
5. Interestingly, it is *right* brain hemisphere that dominates for children in fetus. Left brain also develops much more slowly suggesting the development of cognitive abilities characterizing brain hemisphere takes a longer time. Does left hemisphere continue cognitive differentiation from the level, where right hemisphere stopped? Or do both hemispheres have cognitive abilities potentially? These observations serve as important hints as one tries to understand what lies behind right-left dichotomy. How the left hemisphere differs from the right one. Left hemisphere cognizes: how cognition is realized at fundamental level?

On basis of these observations I disagree with Pinker.

## 1.2 Overall View Suggested By *Musicophilia*

In the sequel will I restrict the consideration to those stories of *Musicophilia*, which I find of special interest from the point of view of TGD inspired theory of consciousness. The outcome is a more precise formulation for the general TGD inspired vision about brain based on basic ideas of quantum TGD.

Zero Energy Ontology (ZEO) implies a new view about the relation between geometric and experienced time and allowing to generalize quantum measurement theory to a theory of consciousness.

Strong form of holography implies the analog of AdS/CFT duality between 2-D representation of physics based on string world sheets and partonic 2-surfaces and 4-D space-time representations. This duality is not tautology and this inspires the idea that these two representations correspond to two modes for consciousness motivating “Left brain talks, right brain sings” metaphor.

1. Language and music could relate to two dual representations of conscious information - local and holistic, cognitive and sensory. Discretization of function/its Fourier transform as a collection of its values at discrete set values of time/frequencies would correspond local/holistic approximations of function. In principle any conscious entity - self- could utilize these two representational modes at appropriate quantum criticality.
2. The holistic “musical consciousness” is assignable to right brain hemisphere and according to the stories of Sacks seems to be characterized by episodal sensory memories. TGD based view about memories relies on ZEO: the memories would be mental images with sensory input from geometric past, genuine sensory experiences of time reversed sub-selves! This picture simplifies considerably and one can see all memories - sensory, cognitive, or emotional - as analogs of phantom pain, which would be also a sensory memory and even more a genuine sensory experience. It is even possible that our biological bodies are used by two selves: right brain hemisphere sleeps when we are awake and vice versa. Even the experiences of epileptics about having double consciousness could be understood.
3. A more concrete realization of “Left brain talks, right brain sings” metaphor relies on the assumption that “magneto-anatomy” is universal. Only the “magneto-physiology” characterized by the values of  $h_{eff}$  characterizing quantum criticality and defining a kind of intelligence quotient dictating the span of long term memory and planned action varies.

$h_{eff}$  would differ for the magnetic bodies of various brain areas, and the spectrum of  $h_{eff}$  for right and left brain would differ and characterize their specializations. For instance, the value of  $h_{eff}$  would be large (small) for the cognitive areas of left (right) brain and small (large) for some higher sensory areas of right (left) brain. Magnetic bodies form a fractal hierarchy and one can characterize even individual cells and neurons by the value of  $h_{eff}$  associated with them. The spectrum for  $h_{eff}$  allows also to distinguish between members of the same species since it defines the skill profile. This obviously goes far beyond the genetic determinism.

## 2 Impressions Created By Stories

The following summary is only a rough sketch about stories of *Musicophilia*, a clumsy attempt to summarize what I see as especially interesting from my own point of view. My interests are selfish (or better to say, TGDeish): I try to abstract what is interesting from the point of view of quantum consciousness theory and I am eager to see whether these stories might help to develop a deeper vision about TGD inspired theory of consciousness. I strongly encourage the reader to read *Musicophilia* and also other books to get more balanced view: these books are rare gems.

### 2.1 Emergence Of Exceptional Music Abilities

Sacks deals with special music abilities. The exceptional musical talents are often - not always - accompanied by profound cognitive in-abilities and one speaks of idiot savants. Savant abilities involve memory feats suggesting that savants remember differently: one could speak of sensory memories.

Savants can also have exceptional mathematical talents such as ability to “see” the decomposition of integers to primes and the ability to perform complex algebraic operations to numbers. Some mathematicians possess these magic gifts: Ramanujan - certainly not a savant - is the classic example. There are also people having exceptional motor skills - consider only piano virtuosos and athletes who must have holistic control of their entire bodies.

These special gifts often emerge as one loses some cognitive abilities assignable to the left brain. Also sensory defects - say blindness at young age - can be accompanied by these abilities.

Also music training initiated at very early age can lead to the development of this exceptional talents. One can ask whether these sensory talents are necessarily accompanied by cognitive inabilities and where they are associated with consciousness different from the standard wake-up consciousness.

1. In music these talents include absolute pitch: person “sees” the pitch of heard or imagined note with an accuracy better than one quarter note and can associate with it note or even frequency. The process is completely spontaneous and involves no comparisons.

An analogy with the perception of visual colors comes in mind. Not only the ratios of frequencies must be rational in good accuracy in order to feel aesthetic but different keys sound different. One example mentioned by Sacks is a Finnish scientist Olavi Sotavalta able to tell the frequency of the sound produced by insect with an accuracy better than Hz.

Absolute pitch can be also a curse for a musician. Since the music piece transformed to different key is not the same piece anymore. Same effect in visual perception is achieved if the colors of painting would be shifted by scaling the frequency in the same manner as the transposition to different key scales the frequencies. This explains why classic compositions are in definite key: this matters for the composer with absolute pitch but for a person without absolute pitch like me this is of course of no significance.

The ability to name the note or tell even its frequency need not require anything outside standard neuroscience and can be explained as a learned association. One can of course ask what association is at the level of conscious experience.

2. Absolute pitch is more general for musicians than average population and appears more often for musicians who have started at young age. Absolute ear is more general in cultures in which the pitch of speech is important (Vietnamese, Mandarin) suggesting that it can develop during early age.

Sacks tells stories about musical savants.

1. Musical savant can have absolute sensory memory for music and reproduce the music piece in detail after hearing it just once: as if she would “see” the entire piece. In one case told by Sacks the memory of savant about read text was phonographic rather than photographic. Similar holistic sensory memory but with all the details present is sometimes associated with visual perception. This kind of holism is different from holism based on abstraction sacrificing the details.

Musical savant can be also highly sensitive to the harmony and the style of the composer and improvise music in this style. This might be understood assuming only that the person has sensory memory about the music and can literally hear it and improvise against this background. If cognition were involved a deep theoretical understanding of music would be required and this is typically lacking.

2. There is a story about people suffering from a congenital disorder known as Williams syndrome and resulting in a strange mixture of intellectual strengths and weakness. Sacks calls these people hypermusical species. They are classified as intellectually retarded (IQ is around 60) but they have unusual command of language, are extremely social and friendly, and have a deep passion for music.
3. Also ordinary persons can have sensory memories or hallucination like states as they fall asleep (hypnagogia) or wake-up (hypnopompia). These experiences seem to be associated with a loss or change of type of consciousness. Could left brain dominance/consciousness

transform to right brain dominance/consciousness or vice versa? If so right brain would not be useless at all: we would spend one half of our life in the alternative mode of consciousness!

4. Also visual and auditory hallucinations might have explanation in terms of right brain dominance. For instance, schizophrenics have hallucinations and sensory memories accompanied by cognitive impairing. Schizophrenic consciousness (as also that of children) has been proposed by Jaynes to correspond to bicameral consciousness, which would have preceded the modern left brain dominated cognitive consciousness.

Why the character of right and left brain consciousness would be so different: to my opinion neuroscience does not answer this question.

## 2.2 Phantom Fingers And The Problem Of Time

One fascinating story is about “phantom fingers”. The brother of philosopher Wittgenstein was a concert pianist, who lost his second arm in World War I. He however experienced the fingers of his right hand as still existing and “played” with it to develop fingerings to music pieces. He experienced of receiving virtual sensory input from the fingers and also sent motor input to the stump as became clear from the movement of the stump.

The neuroscience explanation is that brain contains sensory maps of body parts and the sensory experience is localizable at this kind of representations in sensory cortex. This view has however an unsolved problem. Neurons or neural circuits in various sensory pathways should be somehow different - neurons for quale “red” should be different from those for note G or sensation of touch - but there seems to be no differences.

Naively one could argue that maybe the sensory qualia are localized at the level of sensory receptors. Phantom leg is a standard objection against this idea. But could the naive explanation be correct after all and force to dramatically modify our views about time?

As will be found, TGD based view about the relationship of geometric time and experienced time combined with ZEO indeed allows to consider a different explanation allowing also to understand the sensory memory feats of of idiot savants and providing a general explanation for right-left dichotomy and for why miraculous sensory abilities are often accompanied by cognitive inabilities.

## 2.3 When Music Suddenly Becomes A Passion

Sacks tells real life stories about various fascinating phenomena surrounding music experience: sudden musicophilia - the emergence of special musical talents and deep passion for music; epileptic seizures during which patient hears music with a strange feeling of familiarity; epilepsy induced by music; music imagery allowing to almost hear the imagined music (Beethoven who became deaf is a classic example in this respect); musical hallucinations; etc...

The sudden emergence of musicophilia suggests that right brain consciousness ceases to be inhibited in wake-up state and becomes a dominating part of conscious experience and that sensory memories characteristic for it appear too. This would suggest that right hemisphere is specialized to produce sensory memories.

The dejavu type experiences are of special interest from the point of view of TGD inspired theory of consciousness since they might give a manner to test the vision about the relationship between two times and ZEO based view about memory.

## 2.4 Music And Neurological Defects

Sacks tells how music has helped his patients to cope with various brain defects classifiable as sensory, motor, cognitive, emotional, etc... Some examples suggest that music is not at all so useless outcome of evolution as Pinker argues and that musical right brain consciousness can come in rescue when left brain suffers damage.

1. The defects considered are often those of left hemisphere. Say those of frontotemporal regions leading to semantic dementia (<http://tinyurl.com/zscxotc>), non-fluent aphasia, and changes in social behavior and conduct such as poor impulse controls.

2. (Non-fluent) aphasia is motor defect and due to the damage of Broca's area (<http://tinyurl.com/yb8f7fal>) located in promotor area in the left hemisphere and responsible for the production of speech. The victim loses the ability to produce speech although he remembers the meanings of the words. The patient can however learn to communicate fluently by singing. Singing as a mode of expression is naturally associated with the right brain and one can say that right brain hemisphere comes in rescue.
3. Person can also suffer from fluent aphasia, kind of mirror image of aphasia. Person can produce but not understand speech - in other words cannot assign meaning to the words or sentences that she hears. Fluent aphasia as a receptive defect associated with the damage to the Wernicke's areas in left hemisphere (<http://tinyurl.com/yb8zp5rp>). From neuroscience perspective it is natural to consider the possibility that the patient does not understand what she hears but understands what she says or vice versa. Sacks talks also about "semantic aphasia": I am not quite sure whether he means that the words that the person produces have no meaning to her: this would suggest damage of both Broca and Wernicke areas. What is however remarkable that that the patient can learn to understand communications by singing: right brain again!
4. As opposed to aphasia, amnesia is a defect of right hemisphere. The victim loses completely all episodal memories and becomes a person without past and future: life story can reduce to few seconds and the persons experiences waking up from sleep or re-incarnating again and again and the world is new in every wake-up. Cognitive abilities are not lost and the patient recalls the meanings of words. Sacks tells a moving story about how a victim of amnesia with help of her loving life companion and music gradually manage to rebuild meaning to his life.
5. In some cases the damage to the frontal areas leads to emotional flatness. Person becomes inert, flat, and indifferent -as Sacks expresses it - and loses ability to initiate actions. Sacks tells about a case in which patient seemed to gain back his emotions while singing: impossible by the damage to the frontal lobes if neuroscience view is correct. Episodal memories seem to be characteristic for right brain consciousness. Could temporary right brain consciousness stimulated by singing allow to have episodal memories with emotional content? Could this be an emotional analog of phantom leg.

### 3 TGD Inspired Theory Of Consciousness Very Briefly

The believer in quantum consciousness of course wonders whether these strange findings could be understood in terms of his or her pet theory. First one must try to identify the questions that one must answer if one wants to understand the findings about music and brain described so elegantly by Sacks. My proposal for the list of correct questions is following.

1. What are the quantum physical correlates of mental image? How mental images are born and die? What features are as mental images? What their binding to sensory percepts does mean physically?
2. What is the relationship between geometric time of physicists and the experienced time. What memories are?
3. Do right- and left brain consciousness differ in some fundamental manner and how this is possible taking into account the similar looking neuronal structure? These possibly existing fundamentally different modes of consciousness should have correlates, which belong outside the neuroscience and perhaps even outside the standard physics.

What are these correlates and how do they relate to EEG? Note that EEG is a poorly understood aspect of neuroscience which until hitherto has been regarded as neural noise but is now known to correlate with contents of consciousness and with the state of brain. The strange effects of ELF em fields on vertebrate were indeed the starting point of the TGD based approach to brain. Bio-photons have been known for long time and are now taken seriously and there might be a relationship.

I can answer these questions only on my own behalf and to do it I must introduce the basic notions and ideas of TGD inspired theory of consciousness. I will not go into details here because I have done this so many times and just suggest that the reading of some basic stuff about TGD inspired theory of consciousness. Suffice it to list just the basic ideas and notions.

### 3.1 Basic Ideas Of TGD Inspired Theory Of Consciousness

1. ZEO and causal diamonds (CDs) and hierarchy of Planck constants assignable to quantum criticality are basic notions. Number theoretic vision is also central. In particular, adelic physics fusing real physics and various p-adic physics as correlates for cognition is also basic building brick.
2. Consciousness theory is generalization of quantum measurement theory constructed to solve the basic problems of ordinary quantum measurement theory: observer becomes self described by physics rather than being outsider of the physical world. Weak form of Negentropy Maximization Principle (NMP) [K4] defines the basic variational principle of consciousness and state that the negentropy gain in state function reduction is maximal.
3. The notion of observe as an outsider to the physical world is replaced by that of self. Self corresponds to a state function reduction sequence to the same boundary of CD. In standard quantum measurement theory this sequence does not change the state but in TGD framework the state at the opposite boundary of CD and even opposite boundary changes. This gives rise to the experience flow of time having the increases of the temporal distance between the tips of CD as a geometric correlate. Self dies as the first reduction to the opposite boundary takes place and re-incarnates at the opposite boundary as its time reversal. Negentropy Maximization Principle forces it to occur sooner or later.

Self hierarchy is a basic notion in TGD inspired theory of consciousness. Self experiences sub-selves as mental images. The continual birth and death of mental images supports this view if one accepts the idea about hierarchy. One can also consider identification for what the change of the arrow of time means for mental image. The time inversion of mental images about external world generates the mental image at opposite boundary of CD and this suggests interpretation as memory - something so simple that I discovered it only when trying to understand phantom leg.

4. TGD physics is number theoretically universal. This means that real physics is generalized to adelic physics. Besides real number based physics also p-adic physics assignable to p-adic number fields and their algebraic extensions are introduced and identified as physical correlates of cognition: kind of mind stuff of Descartes besides *res extensa*. Field equations make sense also in p-adic number fields and one can define what preferred extremal of Kähler action mean in p-adic context.

One can speak also about intersection of realities and p-adicities defined by a particular extension of rational physics. Space-time surfaces are characterized by parameters and if these parameters belong to this extension one can interpret space-time surfaces either as real or p-adic: the algebra is formally the same. One can algebraically continue the parameters from the extension of rationals to reals and extensions of p-adic numbers and obtains what might be called fundamental sensory and cognitive representations. One can say that fermions localized at string world sheets define the quantum correlates for Boolean cognition and p-adic space-time sheets its space-time correlates.

5. MBs carrying dark matter identified as  $h_{eff} = n \times h$  phases of ordinary matter define quantum correlates for selves. Magnetic body (MB) has hierarchical onion-like structure and it communicates with biological body using dark photons propagating along magnetic flux tubes. EEG and its fractal generalization make both communication from/control of biological body to/by MB. Dark matter hierarchy can be reduced to quantum criticality and this in turn has deep roots in the adelic physics.

MB is an ideal place for the realization of the two basic representation based on pulses *resp.* frequencies behind “Left brain talks, right brain sings” metaphor. 4-D field representations

could be realized in terms of massless extremals and pulse representations in terms of supra currents assignable with magnetic flux tubes carrying fermionic strings.

The completion of organism-environment double to MB-organism-environment triple would be the extension of the ontology of neuroscience needed. Neuroscience alone would not be enough to understand the strange aspects of brain consciousness.

### 3.2 Hierarchy Of Quantum Criticalities And Strong Form Of Holography

The hierarchy of quantum criticalities reduces to strong form of holography in turn implied by strong form of General Coordinate Invariance (GCI).

1. Strong form of holography states that the information about quantum aspects of physics is coded by second quantized induced spinor fields localized at string world sheets and intersecting partonic 2-surfaces at discrete point sets. Collections of string world sheets and partonic 2-surfaces (briefly 2-surfaces) dictate space-time surfaces identified as preferred extremals of so called Kähler action having vanishing Noether charges in a sub-algebra of so called super-symplectic algebra. These conditions effectively eliminate degrees of freedom so that instead of 3-D holograms one has 2-D holograms.
2. The possibility to code space-time surfaces by appropriate boundary conditions at string world sheets (they carry vanishing classical W fields and possibly also  $Z^0$  fields) means that one can reduce to world of classical worlds to a reduced WCW consisting of the collections of these 2-surfaces. This obviously defines the counterpart of AdS/CFT correspondence. Instead of equivalence of QFT at the  $n - 1$ -D Minkowski space defining boundary of  $AdS^n$  with string theory in the interior of of 10-D  $AdS^n \times S^{10-n}$  one has something which is very near to ordinary holography: the stringy physics at 2-surfaces is dual to the classical physics in the interior of 4-D space-time surface in  $M^4 \times CP_2$ .
3. This duality is not a tautology! All collections of 2-surfaces need not allow a continuation to a preferred extremal of Kähler action. Continuability implies strong correlations between the 2-surfaces so that one cannot take any collections of 2-surfaces and continue it to preferred extremal.

This is true in real sector. In p-adic sectors the situation is different because p-adic differential equations allow integration constants which have vanishing derivative but are piecewise continuous depending on finite number of binary digits of the coordinates. This freedom suggests that the continuation to p-adic 4-surface is always possible.

The interpretation would be obvious in consciousness theory. Strong form of holography in the direction  $2 - D \rightarrow 4 - D$  corresponds to imagination. Space-time surface can be imagined by continuing the 2-D surfaces to 4-D preferred extremals in p-adic sectors and the imagined space-time surface is not unique. In the real sector this imagination need not be possible in real sector. Imagination is unrealistic!

### 3.3 Selves, Their Time Reversals, And Memories

The notion of self provided by ZEO predicts that selves have time reversals. Could this allow to understand the strange findings about idiot savants?

In this framework the idea about memory recall as communication with the brain of geometric past (time reflection for signals propagating to past) can be formulated more precisely. Memory recall quite generally corresponds to a temporary falling asleep/death of sub-self (mental image) followed by immediate re-incarnation in geometric past and giving rise to mental image located in past.

I have proposed variants of this mechanism such as time like entanglement and emission of signal from the brain of the geometric past back. Time-like entanglement does not seem to be necessary for having sensory memory and signals to geometric future would correspond to a further re-incarnation of sub-self with the original arrow of time. This is possible but does not seem necessary.

Association with the Sacks's stories stimulates fascinating questions.

1. Is memory recall this kind of re-incarnation of sub-self (mental image) in the geometric past? This kind of experience would be just like ordinary experience having both sensory, motor, cognitive, and emotional aspects. Could the sensory memories associated with right brain consciousness explain the memory feats of the idiot savants?

For instance, the ability to re-experience the music piece heard once would make possible to repeat it by playing together with the second self in past. Combined with absolute pitch this would give powerful music abilities.

Sacks tells also about epileptic seizures in which one hears music and experiences "double consciousness". Could mental images in right and left hemisphere be simultaneously awake and create this doubling of consciousness?

2. Could the pain in phantom leg be sensory memory that is genuine sensory experience associated with the leg, which still exists in the geometric past? Could all memories be actually conscious experiences of time reversed sub-selves? Could Wittgenstein's brother's phantom fingers exist in the geometric past before World War I and would he "play" piano with the hand of geometric past?
3. Could the patient who had lost emotions and seemed to get it back - not possible according to neuroscience - while singing have emotional counterpart of phantom leg sensations so that he had genuine emotional mental images from the time time before accident? These memories would be analogous to the sensory memories of idiot savants allowing their memory feats and to the sensory memories created by the stimulation of temporal lobes. Why sensory memories are so rare has a simple explanation: their interference with sensory input from recent moment could have disastrous effects. Most memories are non-sensory sine they can be distinguished from the sensory input.
4. Could the sub-selves (mental images) associated with right brain be time reversed with respect to the left brain sub-selves? Naively left brain dominance means that right brain "sleeps"- or lives in geometric past, remembers in the scale of entire hemisphere. Could it be that when left hemisphere is awake and "remembers geometric future" (precognizes, plans, predicts), right hemisphere is also awake but remembers geometric past. Do the time directions of right and left selves change during sleep? Are we living two lives? Is the right hemisphere the "Ka" of ancient Egyptians?
5. The feeling that the music heard during during the epileptic seizure is familiar brings in mind dejavu experience. For instance, one can imagine that a cognitive representation about the experience was formed as the original experience occurred and still exists in the geometric "now". Could this create the sensation of familiarity.
6. Sacks tells about a patient with amnesia with time span of autobiographical memory measured in seconds but having usual cognitive abilities assignable to left hemisphere. The simplest explanation is that the region of right brain responsible for autobiographical memories was damaged and the value of  $h_{eff}$  associated with the corresponding magnetic body was reduced dramatically.

### 3.4 Hallucinations From The Point Of View Of ZEO

### 3.5 Hallucinations From The Point Of View Of ZEO

Sacks tells also about music hallucinations and emphasizes that is not clear these experiences can be always regarded as hallucinations. The following TGD inspired considerations are not specific to music hallucinations.

1. If one accepts that the feedback from brain or MB to sensory organs as virtual sensory input is possible then imagination differs from hallucinations only in that the virtual sensory input stops before it reaches the sensory organ.

On the other hand, imagery as a completion of string world sheets and partonic 2-surfaces to - in general non-unique - 4-D surface could be possible in p-adic sectors (p-adic pseudo-constants) whereas in real sector it is possible only partially in the general case. This applies also to virtual sensory inputs: they can be imagined but not necessarily realized.

The two definitions are consistent if the impossibility of complete continuation to real sector corresponds to the impossibility of the virtual sensory input to reach the sensory organ.

2. The possibility of time reversal for mental images makes possible episodal memories as genuine mental images in geometric past. One cannot speak of hallucinations now, and even talking about memory is somewhat misleading since the event happens for the first time with respect to subjective time. It would be better to talk about multi-time experiences.

The experiences in which person hears music could be therefore genuine episodal memories/real experiences. Dreams could have both the hallucinatory and sensory memory aspect. My own dreams are often localized to my childhood and youth but cannot be regarded as experiences about real events - the interpretation as time reversed imagery could be considered.

3. I have considered the possibility that some experiences induced by psychedelics - such as experiences of meeting representatives of some exotic life forms - could be real [K10, K13]. The objection that finite light velocity makes these encounters impossible can be circumvented in ZEO since signals can propagate to geometric past and reflect back in time direction. Essentially seeing in time direction would be in question.

From consciousness theory perspective this could mean simple time reversal of subself so that the sensory mental images are in geometric past. Mechanism would be same as in the case of long term memory/genuine experience except that the sensory mental image represents representative of distance civilization rather than something generated in own brain. Even in the case of music "hallucinations" it is not clear whether the mental image can be localized in the own brain in past! If the process is a sequence in which the sub-self dies and reincarnates several times it can involve also classical communication and could give rise to memories, which are not sensory ones.

One can argue that the size of the CD assignable with human as conscious entity poses strong limitations on the distance of the civilization. The naive first guess is that the size scale of this CD corresponds to the human light life - less than 100 light years typically. This assumption is however un-necessarily strong. The size scale of personal CD could be considerably longer: in this case however the sensory mental images about body and environment would not be near the boundary of CD but in its interior. The largest value of  $h_{eff}$  in the personal hierarchy of sub-selves defines the size of personal CD and at the same time the span of long term memory serving as a kind of IQ. The higher this IQ, the higher the probability of this kind of communications would be.

There are still many unanswered fundamental questions about CDs possibly relevant for the considerations above. Can one assume that space-time surfaces can continue outside the boundaries of CD so that CD could be seen as spotlight of consciousness? Or does CD define its sub-Universe in the sense that it is nothing outside it or that it is impossible to say anything about the situation outside it? How CDs of various size scales interact and can they overlap?

## 4 Two Modes Of Of Consciousness

In the following the idea about two modes of consciousness basically reducing to strong form of holography is developed in more detail.

### 4.1 Conscious Holograms And Two Kinds Of Fundamental Representations

The idea about brain as hologram was introduced in neuroscience long time ago by Karl Pribram [J1] (<http://tinyurl.com/ydyv6ohr>) and there is considerable support for it although it is also

clear that at the higher levels of the evolutionary hierarchy brain functions can be localized. Also living matter can be seen as a hologram in the sense that DNA contains the information about the entire organism. I introduced for long time ago the notion of conscious hologram [K1].

Strong form of holography generalizes this notion to a basic law of quantum physics and since consciousness theory reduces to quantum measurement theory in ZEO, of consciousness. The generalization of AdS/CFT realizing strong form of holography is not a tautology since the collections of 2-surfaces do not always define a realizable imagery. This suggests that dual representations give rise to two different fundamental representations of conscious information.

The first representation is in terms of collections of 2-surfaces replacing a naive discretization of space-time surface by co-dimension 2 discretization dynamical in the sense that physical state itself defines its discretization at both quantum and classical level. String world sheet discretization is a generalization of 4-D discretization in terms of world lines reducing to 3-D discretization using discrete points.

1. Finite measurement resolution is a key notion of quantum TGD. One realization is in terms of string world sheets. At the level of “world of classical worlds” (WCW) it is realized as discretization of general coordinate invariant parameters characterizing the 2-surfaces [K17].

This allows to avoid problems related to general coordinate invariance and symmetries that plagued the earlier proposal based on cognitive maps of discrete points sets of real space-time surfaces to p-adic ones or vice versa.

There is no local correspondence between real and p-adic space-time surface by a common points of imbedding space in the algebraic extension of rationals as suggested in the earlier proposal [K14]: the p-adic-real connection is global. Real and p-adic preferred extremals share 2-surfaces with parameters in algebraic extension of rationals identifiable as either real or p-adic numbers.

2. The existence of 4-D representation is guaranteed by strong form of holography if additional correlations between 2-surfaces hold true. For generic 2-surfaces continuation is possible in p-adic sectors but is not unique and can be interpreted in terms of imagery.
3. Cognitive representations would naturally correspond to this 2-D representation since the reduction of information would be huge. Since the continuation to p-adic space-time surface for obvious reasons is not unique, conceptualization abstracting out the common aspects of the 4-D representations is necessary and forces the development of cognition and abstraction to see what the correlations between 2-surfaces guaranteeing realizable imagery are. Abstraction allows symbolic representation and imagination.
4. The fundamental representation would be in terms of fermionic strings connecting partonic 2-surfaces, which can have arbitrarily large size ( $h_{eff}$  hierarchy). Sound is a phenomenon which is always associated with the relative motion of particles rather than single particle and in this sense differs from elementary particles. The oscillations of these strings could define sound as a fundamental phenomenon, and fermionic strings could be highly analogous to strings of music instrument.
5. At the light-like partonic orbits defining the “lines” of generalized Feynman diagrams (or rather generalized twistor diagrams) the signature of the induced metric changes from Euclidian to Minkowskian. These light-like 3-surfaces correspond to boundaries of physical objects and the ends of strings at them define fermion lines in twistor diagrams [K11]. At partonic 2-surfaces at the boundaries of CDs the discretization consists of a collection points in accordance with naive expectations.

Second representation would be in terms of 4-D surfaces themselves and corresponds to the sensory representations in real context. 4-D real representation is much more detailed, concrete, and holistic. In some cases the concreteness of the representation makes it superior. Consider only the miraculous feats of mathematician Ramajunan or physicist Tesla, who could see his thoughts. This representation cannot of course not complete and by the huge super-symplectic symmetries the representation should involve only very general characteristics. This representation would be naturally realized at the level of field body (massless extremals and magnetic body).

1. The flux tubes of the MB carrying dark fermions realized at fermionic string world sheets would be part of the 4-D representation. Magnetic flux tubes are indeed in a key role in TGD inspired theory of consciousness and of living matter.
2. Massless extremals (MEs or topological light rays) accompanying magnetic flux tubes and having also tube-like structure are extremals of Kähler action (very probably also preferred ones) represent a propagation of arbitrary radiation pulse to either direction but the superposition of pulses propagating to opposite directions is impossible. The shape of the pulse is not changed during propagation, the signal is precisely targeted, and it propagates with maximal signal velocity. Classic analog of laser beam is in question.
3. Cyclotron frequencies, which are typically determined by lengths of magnetic flux tubes and by the values of magnetic fields at them, would be a natural parameters capturing gross geometric features of space-time surface. Note that also Kähler magnetic field is a geometric notion in TGD framework since classical gauge fields are geometrized in terms of sub-manifold geometry.

Also the scale of CD determined by the temporal distance between its tips defines a natural resonance frequency spectrum.

### 4.2 How Nerve Pulses And EEG Could Relate To 2-D And 4-D Representations?

How nerve pulses and EEG relate to the 2-D and 4-D fundamental representations? The answer is not straightforward. The description of neuroscience is not based on many-sheeted space-time having fractal hierarchy of space-time sheets, and there are many layers of approximations involved. It also seems that neuroscience misses an important element related to MB - the “motor actions” of MB (hierarchy of them) and MEs, in particular braiding of flux tubes identifiable as braid strands and are accompanied by strings.

1. Resonance frequencies of EEG realized using MEs parallel to flux tubes could relate to frequency representation serving as a correlate for large scale quantum coherence. MB would coordinate the behavior of brain in this manner. alpha band and kHz synchrony would be examples of this.
2. Neuroscience does not provide direct analog of 2-D representation responsible for cognitive memories. In TGD based model for DNA as topological quantum computer [K3, K12] it is assumed that nucleotides or codons are connected by flux tubes to the lipids of the internal lipid layer of the nuclear or even cell membrane. Same can hold true for microtubules and axonal membrane. Also connections between lipid layers and connections of outer lipid layers to lipid layers of other cell membranes are possible.
3. Axonal microtubules are very natural as far as cognitive memory representations are considered. The propagation of nerve pulse induces flow of the 2-D liquid defined by lipids and induces braiding of the flux tubes connecting axonal membrane to microtubules. One has two braidings: time-like braiding analogous to that generated by dancers on the floor and space-like braiding generated if dancers feet are connected to a wall (now DNA strand). Space-like braiding stores time-like braiding to memory. The 2-D representation would be naturally associated with the braid strands idealized as strings. These effectively 2-D braid representations would form a fractal hierarchy and be basic aspect of biology.
4. The value of  $h_{eff}$  for the magnetic body part associated with a given brain area defines how long the span of long term memory and planned action for the brain region in question is and can be used to explain also the difference between right and left hemispheres as also difference between individuals without any additional assumptions. Quite generally, the spectrum of  $h_{eff}$  would explain the skill profile of individual.

### 4.3 How The Two Representations Could Be Realized At The Level Of MB?

How the two representations could be realized at MB - ME complexes?

1. Effective 2-D representation could involve supra currents propagating along the flux tubes of MB. Supra current is of course practical higher level notion idealizing fermions and Cooper pairs with point like objects. At basic level one has pairs of fermions at different partonic 2-surfaces connected by strings. The string connecting the partonic 2-surfaces of the members of Cooper pair and its oscillations would correspond to the fundamental level.

A possible realization of effectively 2-D representation in terms of fermion currents or supra currents is discussed in [K6] [L4, L3]. The discussion was inspired by the observation that  $\text{SmB}_6$  behaves in “schizophrenic” manner in external magnetic field: it is topological insulator but conducts current in scales of order  $10^{-4}$  m and conduction velocity is million times higher than expected [L4].

In de Haas-van Alphen effect (<http://tinyurl.com/yeh7b9n8>) the magnetization depends periodically as function on the inverse value of the external magnetic field. The effect leads to an explanation of the paradoxical phenomenon. Magnetic flux tubes become carrier of dark electron currents at quantum criticality defined as value of magnetic field at which a new cyclotron orbit emerges at the surface of flux tube with fixed thickness. This flux tube must correspond to electron energy which is very near to the Fermi energy. This indeed requires quantum criticality.

If electron density (and thus Fermi energy) is kept constant, quantum criticality is realized only for discrete values of magnetic field strength allowing the generation of quantum critical cyclotron orbit carrying dark electrons (say). If electron density can vary and magnetic field strength is fixed, then certain values of electron density allow quantum criticality and dark electron current along flux tube. The variation of electron density could be the natural control variable in the case of nerve pulses. Part of electron current would leak out to MB as dark current.

2. Frequency representation could be realized in terms classical em fields (MEs) assignable to EEG and its variants and having as quantum counterparts dark photons assignable to flux tubes. EEG resonance frequencies should correspond to cyclotron frequencies. Flux tube thickness determining the value of magnetic field is at criticality must be such that the cyclotron frequencies correspond to generalized Josephson frequencies in order to make possible the communication of the variations of membrane potential to the MB. In both cases quantum criticality making possible the presence of dark matter at flux tubes is necessary and makes possibly transformation of electrons to dark matter phase with  $h_{eff}/n = n$ .

### 4.4 What The Specialization Of The Brain Hemisphere To 2-D Or 4-D Representation Could Mean?

“Right brain signs, left brain talks” metaphor should have concrete content and the 2-D and 4-D representations could provide this content. The challenge is to understand how this specialization might be realized.

The specialization to a particular representation cannot take place at the level of neuro-anatomy. The specialization should therefore occur at the level of MB.

1. Could the magneto-anatomies of the left- and right MBs differ? Or is the magneto-anatomy universal and differentiation leads to different magneto-physiologies. The latter option looks more feasible. Differentiation would select the available quantum criticalities in turn selecting which representation is used. This option is certainly the most flexible one.
2. Also the values of  $h_{eff}$  involved characterizing the size of MB matter: the larger the value of  $MB$ , the higher the magnetic IQ. This would suggest that magnetic bodies are present but the time scale of corresponding long term memories and planned actions depends on the value of  $h_{eff}$ . The growth of magnetic body would be intellectual development.

3. In left hemisphere only cognitive areas (including frontal lobes) could have access go MB with large  $h_{eff}$  or access to it (ability to generate the needed quantum criticality) making possible long term cognitive memories. In right hemisphere only sensory areas could have access MB with large  $h_{eff}$ .
4. The universality of magneto-anatomy is also consistent with the enormous flexibility of brain. For instance, for patients with very bad epileptic seizures brain hemispherectomy (<http://tinyurl.com/yatszpb5k>) can be the only possible treatment. Usually this operation is carried out at age below four years since at this age brain is still developing and at higher age complications appear (I do not know whether there exists detailed data about the character of these complications). Surprisingly, the operation has no apparent effect on personality or memory (<http://tinyurl.com/nppk9vc>)! In particular, entire left or right hemisphere can be removed.
5. The most flexible and still metabolically feasible (by  $E = h_{eff}f$  large  $h_{eff}$  photons are metabolically very costly!) option is that the magneto-anatomy of all cells is same and that the character of quantum criticality available determines, which option can be used. The specialization would be at the level of magneto-physiology fixing what control knobs are available and large  $h_{eff}$  photons would be generated only when needed.

This option would be minimum option conforming with “right brain sings, left brain talks” metaphor. Even if the access is possible at both sides, metabolic economy would favor specialization meaning that left hemisphere develops cognitive long term memories and skills and right hemisphere their sensory counterparts. The observation that the damage for the left hemisphere causes cognitive defects can be understood: right brain hemisphere comes in rescue but it has generated only long term sensory memories with large  $h_{eff}$  whereas cognitive memories are short term memories and cognitive skills are much weaker. Also the loss of autobiographical memory in the damage of right hemisphere can be understood if right brain is specialized to produce this kind of episodal memories.

This option also allows to understand the magic mathematical skills if these skills are associated with some region of the right hemisphere. The skill in question would be more analogous to sensory perception rather than cognition. For instance, a possible explanation for the miraculous ability to “see” the decomposition of an integer to primes is that it is a visual representation for the dark phase transition in which a phase characterized by  $h_{eff}/h = n_1n_2$  transforms to a phase characterized by  $h_{eff}/h = n_i, i = 1$  or  $2$ .

## 4.5 Fractal Hierarchy Of Binary Structures And Realization Of Two Kinds Of Representations

Many basic structures of living matter serving as basic units of consciousness have binary structure and this has already earlier led to the idea that one has fractal hierarchy of binary structures analogous to pairs of brain hemispheres. It seems natural to assume that pulse and frequency representations are realized and the right-left asymmetry suggests that second member of pair produces frequency representation and second member the pulse representation.

Twin primes are pairs  $(k, k + 2)$  of primes and seems to be of special importance. As **Table 1** below demonstrates, there is large number of these pairs in biologically relevant length scales and they might correspond to twin structure forming a fractal hierarchy especially interesting from the point of view of consciousness. The members of first few twin primes are of form  $n \pm 1$  for  $n = 4, 6, 12, 18, 30, 42, 60, 72, 102, 108, 138, 150, 180, 192, 198, 228, 240, 270, 282, \dots$

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

In the following only few examples are considered.

1. DNA double strand has binary structure: one strand is active and second one passive as far as transcription is considered. There are also portions for which the two strands are identical: these correspond to palindromic sequences of DNA. These palindromes serve as control units initiating transcription of gene.

**Table 1:** Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair  $(167, 13^2 = 169)$  although  $k = 169$  is not prime. The two largest scales could relate to structures appearing in brain. Note that the primes  $k = 151, 157, 163, 167$  correspond to Gaussian Mersennes. The appearance of so many Gaussian Mersennes in the length scale interval between cell membrane thickness and the size of cell nucleus is a number theoretical miracle.

$(k, k + 2)$	(137, 139)	(149, 151)	$(167, 169 = 13^2)$	(179, 181)
$L_e(k)$	.78 <i>A</i>	5 <i>nm</i>	2.5 $\mu$ <i>m</i>	.16 <i>mm</i>
$(k, k + 2)$	(191, 193),	(197, 199)		
$L_e(k)$	1 <i>cm</i>	8 <i>cm</i>		

An analogous symmetric structure in brain is pineal gland, which Descartes identified as seat of soul. One might think that MB controls gene expression through the palindromes and MB of the entire brain via the pineal gland. There are also other glands performing hormone control, and they could also serve as lower level relay stations controlling brain hemispheres rather than entire brain.

2. Nuclear and cell membranes consist of two lipid layers and correspond to *primary* p-adic length scales  $k = 149$  and  $k = 151$  (both integers are primes): the latter corresponds to Gaussian Mersenne. I have proposed that this double layer has the structure of generalized Josephson junction [K8]. Similar Josephson junction structure could be associated with DNA double strand. The generalized Josephson frequencies would give rise to EEG in terms of large  $h_{eff}$  dark photons with energies in visible and UV range characterizing bio-photons.

Frequency modulation of generalized Josephson frequencies by nerve pulse patterns would assign to the nerve pulse representation at axons the frequency representation communicated to the MB. This leads to ask whether the Josephson currents between brain hemispheres possibly running through corpus callosum define give rise to an analog of EEG at low frequencies? This Josephson junction would be of special importance for the music consciousness.

3. Twin primes could define binary pairs forming both kinds of sensory representations. The pair (179,181) corresponds to primary p-adic scales (.16-.32) mm perhaps assignable to epithelial sheets, which are double cell layers appearing in skin. The pair (191,193) corresponds to primary scales (1.0,2.0) cm perhaps assignable to the basic structural units of cortex. The pair (197,199) corresponds to primary length scales (9, 18) cm naturally assignable to brain hemispheres.
4. There are also several highly interesting primary p-adic length scales associated with twin primes and Gaussian Mersennes possibly having relevance as size scales of structures relevant for biosphere but these will not be discussed here.

The *secondary* p-adic time scales associated with Gaussian Mersennes and twin primes  $(k, k + 2)$  might be interesting from the point of view of memory long.

1. Consider first Gaussian Mersennes. For  $k = 127$  associated with electron the secondary time scale is .1 seconds defining the fundamental biorhythm and this time scale defines the duration of sensory mental image. For  $k = 151$  associated with Gaussian Mersenne the secondary time scale is by a factor  $2^{151-127} = 2^{24}$  longer and roughly  $1.6 \times 10^6$  seconds, about 18 days. For  $k = 157$  the time scale is 64 times longer -  $10^8$  seconds, roughly 3 years. For  $k = 163$  the time scale is 64 times longer and about 200 years. Could these time scales define preferred size scales for MBs and time scales of long term memory? Note that the scales is of order Earth circumference already for  $k = 127$ .
2. The twin pair (137, 139) could correspond to time scales 3.2 sec and 6.4 sec perhaps assignable to short term memory. The twin pair (149, 151) would correspond to time scales of 9 days and 18 days.

## 4.6 Absolute Pitch

Absolute pitch can be seen as right brain aspect of consciousness. Sensory memories are involved and I have already discussed the TGD based model for them. Sensory memories allow to literally hear the piece of music repeatedly and build associations to note, piano key, or even to frequency.

That rational frequency ratios (in Pythagorean scale coming as powers  $(3/2)^k$  reduced to the lowest octave by octave equivalence are preferred might relate to the number theoretic vision about evolution as emergence of higher dimensional algebraic extensions of rationals. The lowest level would correspond to rational numbers.

Absolute scale does not only mean that the ratios of frequencies that a person with absolute pitch prefers are rational. It means also that there is indeed absolute scale and music in other scales is different and in some cases even non-recognizable as same music piece.

Interestingly, the range of visible frequencies is one octave suggesting that there might be a deep connection between music and vision. Sacks tells that already Newton considered the possibility that the 8 notes correspond to some colors of light. TGD inspired mode geometric model for harmony [K7] [L2, L1] leads to analogous correspondence.

1. I have considered this connection in detail in the geometric model of harmony providing also a model of genetic code [K7]. The first observation is that 12-note scale has as many notes as there are vertices at icosahedron, one of the Platonic solids. Second observation is that icosahedron has 20 triangles as faces and that also the number of amino-acids is 20.

This inspires the idea that given harmony corresponds to so called Hamiltonian cycle, which is a closed (by octave equivalence) non-self-intersecting curve connecting neighboring vertices at icosahedron and going through all vertices. Single step between neighboring points of the curve correspond to single quint (scaling of frequency by factor  $3/2$ ): the idea is that notes differing by quint are 3-adically near to each other. Each Hamiltonian cycle defines one particular harmony with 3-chords defined by the 20 triangles. There are 17 different harmonies and 11 of them have symmetries.

2. The surprise is that one can understand the degeneracies of the genetic code defined as numbers of DNAs coding for given amino-acid for 60 DNAs in terms of the symmetries of Hamiltonian cycles. 4 DNAs are however lacking. There is also second problem: 12 quints corresponds to slightly more than 7 octaves so that projection to the same octave gives 13 rather than 12 notes with two notes very near to each other: this problem was familiar already for Pythagoras.

The handling of these problem requires addition of tetrahedron bringing in also 4 additional DNAs and 2 additional amino-acids known to be coded in some circumstances by DNA in all organisms (Pyl and Sec). One obtains actually two slightly different genetic codes, and can ask whether the two DNA strands speak different dialects of the same language.

3. The model maps genetic codons consisting of 3 nucleotides to triangles to 3-chords and the allowed 64 chords define what I call bio-harmony. 256 different bioharmonies consistent with genetic code are predicted. These harmonies have as buildingbricks harmonies consisting of 20 allowed 3-chords.
4. The model leads to the proposal that the fundamental realization of the genetic code could be in terms of dark photons with frequencies, which could be in the range of audible frequencies. Also the representation in terms of dark photons is suggestive and since living matter is piezoelectric it could allow to transform dark phonons to dark photons and vice versa.

If the last step of this argument is accepted, the problem of understanding absolute scale reduces to the physical identification of the special dark cyclotron frequency - call it  $f_0$ . It could correspond to note C (say). Neuroscientist would explain this special frequency as a resonance frequency of some neural circuit - for instance, thalamocortical resonance frequency around 40 Hz is assumed to result in this manner. In TGD framework the presence of MB changes the situation.

1. The first step is to accept that the identification of gravitational Planck constant  $\hbar_{gr} = GMm/v_0$  with  $\hbar_{eff} = n \times \hbar$  [K16, K15] ( $M$  and  $m$  are masses connected by magnetic flux

tube mediating the gravitational interaction and  $v_0$  is velocity parameter [K9, K15, ?]). This fixes the value of  $h_{eff}/h = n$  and implies that the spectrum of cyclotron energies does not depend on the mass of charged particle and depending on the magnetic field strength only. Bio-photon energy spectrum corresponds to the spectrum of magnetic field strengths. The condition that the energy spectrum is in the scale of bio-photon energies belonging to the range of excitations energies of biomolecules (visible and UV range) fixes the value of  $n$  if the value of magnetic field and mass of charged particle is fixed to.

2. An interesting - perhaps too science fictive - possibility giving a justification for 12-note scale at fundamental level would be that the octave spanned by visible photon energies corresponds to 12-note scale realized as powers of  $3/2$  modulo 2 for this magnetic field strength, call it  $B_0$ . In this case different ions would correspond to scaled variants of basic spectrum with scaling factor given the ratio  $q_0 A_i / q_i A_0$  of mass numbers, where  $A_0$  is the mass number of the reference ion and  $q_0$  is its charge, say  $H^+$ . One would obtain preferred keys related by these scalings. This is of course only one possibility.

Some bio-molecular transition energy fixes the basic frequency and therefore the value of  $B_0$  and perhaps also other frequencies. DNA absorbs UV light at wavelength of 260 nm and energy 4.8 eV: the highest energy of visible photon energy is around 3.2 eV and correspond to wavelength of 390 nm. The ratio of this energies is  $3/2$  - one quint! Maybe this is not a pure accident.

$B_0 = .2$  Gauss is suggested as the preferred value of endogenous magnetic field by the original observations that ELF em fields have quantal looking effects on vertebrate brain [K5, K2]. If this value is accepted, one can deduce the value of  $h_{eff}/h = n$  for reference ion. The optimal choice is to take the reference ion as  $H^+$  since the masses are in a good approximation integer multiples of proton so that the values of  $h_{eff}$  are approximately  $n_i(ion) = A_i \times n_i(proton)$  and thus integer valued. For  $B_0 = .2$  Gauss proton cyclotron frequency is 300 Hz. Ion frequencies are in EEG spectrum. The higher powers of  $3/2$  give higher octaves and frequencies in audible range. 10 octaves would give audible range.

3. The two kinds of representations are possible if the quantum criticality condition for cyclotron resonance in case of frequency representation or for the generation of electronic supra currents in the case of pulse representation is satisfied. This would fix the value of the magnetic field strength  $B_0$  for  $H^+$ .

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