Exploration

Comparison of Jeremy England's View about Life and Evolution with TGD Approach

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Abstract

The thermodynamic approach of Jeremy England to life has gained a considerable attention. In this article I will summarize this approach and compare it with TGD vision. The generalization of the thermodynamic approach to TGD framework leads to surprising new insights about the thermodynamic conditions making life and consciousness possible. The new elements relate to zero energy ontology (ZEO), hierarchy of Planck constants labelling levels in a hierarchy dark matter assignable with quantum criticality, the role of macroscopic quantum coherence associated with gravitation and strong form of holography. Rather surprisingly, the TGD counterparts of Hawking temperature and Hagedorn temperature seem to be crucial for life and correspond to physiological temperature scales. Near Hawking temperature the special features of ZEO become manifest meaning that time reversals of "selves" (mental images) are generated with a considerable rate in heat bath and long term memory and planned action become possible.

1 Introduction

I had an intensive discussion with my son-in-law Mikko about the work of Jeremy England [1] (`http://tinyurl.com/o64rd7o`). The article of the link is probably the most aggressive hyping I have ever seen but this should not lead to think that a mere hype is in question. There is also another, not so heavily hyped popular article at `https://www.quantamagazine.org/20140122-a-new-physics-theory-of-life/`. The material at the homepageof England's lab (`http://www.englandlab.com`) gives a good view about the work of England for those who cannot tolerate hyping.

England's work is indeed very interesting also from TGD point of view although it is based on standard physics.

In this article I will summarize this approach and compare it with TGD vision. The generalization of the thermodynamical approach to TGD framework leads to surprising new insights about the thermodynamical conditions making life and consciousness possible. The new elements relate to zero energy ontology (ZEO), hierarchy of Planck constants labelling levels in a hierarchy dark matters assignable with quantum criticality, the role of macroscopic quantum coherence associated with gravitation, and strong form of holography. The TGD counterparts of Hawking temperature and Hagedorn temperature seem to be crucial for life and correspond to physiological temperature scales. Near Hawking temperature the special features of ZEO become manifest meaning that time reversals of "selves" (mental images) are generated with a considerable rate in heat bath and long term memory and planned action become possible.

1.1 Basic ideas of England's theory

I try first to summarize England's vision.

1. Non-equilibrium thermodynamics (NET) is the starting point. NET has been for decades the theoretical framework underlying the attempts to understand living matter using the principles of self-organization theory. Living matter is never an isolated system: dissipation would take it to a

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totally dead state in this case - nothing would move. Water in the pond when there is no wind, is a good example.

Self-organization requires an external energy feed - gravitational potential energy liberated in water flow in river or electric power feed to the hot plate below a teapot. This energy feed drives the system to a non-stationary state far from a thermal equilibrium state. Dissipation polishes out all details and leads to an asymptotic spatio-temporal self-organization patterns. The flow in a river and convection in the heated teapot. With high enough energy feed chaos emerges: water fall or boiling of tea pot.

2. The basic hypothesis of England is that evolution means increase in the ability to dissipate. This looks intuitively rather obvious. The evolving system tends to get to a resonance with the energy feed by oscillating with the same frequency so that energy feed becomes maximal and therefore also dissipation. The basic rule is simple: choose the easy option, ride on the wave rather than fighting against it! For instance, the emergence of photosynthesis means that the systems we call plants become very effective in absorbing the energy of sunlight. In this framework essentially all systems are alive to some degree.

   Dissipation means generation of entropy. Evolution of life and conscious intelligence would mean maximal effectivenes in the art of producing disorder. Now I am perhaps exaggerating. One should speak about "system's maximal ability to transfer entropy out of it": life is not possible without paper baskets. One could argue that the development of civilization durig last decades demonstrates convincingly that evolution indeed generates systems generating disorder with a maximal rate.

   One could argue that the definition is too negative. Living matter is conscious and there is genuine conscious information present. The fact is that evolution involves a continual increase of conscious information: the exponential explosion of science is the best proof for this. England's vision says nothing about it. Something is missing.

   It is however quite possible to imagine that the principle of maximal entropy generation is true and that the increase of the ability to produce entropy is implied by some deeper principle allowing to speak about living matter as something tending to increase conscious information resources. To formulate this idea one needs a theory of consciousness, thermodynamics is not enough.

3. England has a further idea. The evolution life is not climbing to Mount Everest but coming down from it. Life emerges spontaneously. This is definitely in conflict with the standard wisdom, in particular with the thermodynamical belief on thermal death of the Universe as all gradients disappear. Darwinian evolution would be a special case of a more general phenomenon, which could be called dissipation driven adaptation (DDA). I made a head-on-collision with this principle in totally different framework by starting from quantum criticality of TGD: if took time to fully realize that indeed: evolution could be seen as a sequence of phase transitions breaking in which certain infinite-dimensional symmetry was spontaneously broken to become just the same symmetry but in longer scale!

   Standard thermodynamics predicts the heat death of the Universe as all gradients gradually disappear. This prediction is problematic for England's argument suggesting that differentiation occurs instead of homogenization. Here the standard view about space-time might be quite too simplistic to overcome the objection. In TGD many-sheeted space-time comes in rescue.

   Here is an example about England's argumentation. It seems intuitively clear that replication increases entropy (it is not however clear whether just the splitting into pieces is even more effective manner to increase entropy!). This would suggest that DDA forces the emergence of replication. Very effective dissipators able to replicate, would increase the total effectiveness in dissipation and be the winners. The proposal to be tested is that bacterial mutations , which are best replicators are also best dissipators.

1.2 What is missing from England's theory?

What is missing from England's theory? The answer is same as the answer to the question what is missing from standard physics.

1. What is conscious observer - self?

   Observer, which remains outsider to the physical world in the recent day physics - both classical and quantum. Hence one does not have a theory of consciousness and cannot speak about conscious information. Thermodynamics gives only the notion of entropy as a measure for the ignorance.

   Therefore there is a long list of questions that England's theory does not address. What are the physical correlates of attention, sensory perception, cognition, emotions relating closely to information, etc.? Is there some variational principle behing concious existence, and does it imply evolution? Could second law and DDA be seen as consequences of this variational principle?

   England does not say much about quantum theory since he talks only about thermodynamics but his hypothesis is consistent with quantum theory. The restriction to thermodynamics allows only statistical description and notions like macroscopic quantum coherence are left outside.

2. What is life?

   Again one has a long list of questions.

   What it is to be alive? What distinguishes between living and inanimate systems. What it is to die? How general phenomenon evolution is: does it apply to all matter? Also notions like self-preservation and death are present only implicitly in an example about a population of wine glasses whose members might gradually evolve to survive in an environment populated by opera sopranos.

   One can make also other kinds of questions. What really happens in replication? What is behind genetic code? Etc...

   England is a spiritual person and has made clear that the gulf between science and spirituality is something which bothers him . England even has the courage to use the word "God". Therefore it sounds somewhat paradoxical that England avoids using the concepts related to consciousness and life. This is however the only option if one does not want to lose academic respectability.

2 How does England's theory relate to TGD?

It is interesting to see whether England's vision is consistent with TGD inspired theory of consciousness, which can be also seen as a generalization of quantum measurement theory achieved by bringing the observer part of the quantum physical world. In TGD framework several new principles are introduced and they relate to the new physics implied by the new view about space-time.

1. The new physics involves a generalization of quantum theory by introducing a hierarchy of Planck constants $h_{eff} = n \times h$ with various quantal length and time scales are proportional to h_{eff}. h_{eff} hierarchy predicts a hierarchy of quantum coherent systems with increasing size scale and time span of memory and planned action. h_{eff} defining a kind of intelligence quotient labels the levels of a hierarchy of conscious entities.

   h_{eff} hierachy labels actually a fractal hierarchy of quantum criticalities: a convenient analogy is a ball at a top of ball at the top..... The quantum phase transitions inreasing h_{eff} occur spontaneously: this is the TGD counterpart for the spontaneous evolution in England's theory. Dark matter is what makes system alive and intelligent and thermodynamical approach can describe only what we see at the level of visible matter.

2. Second key notion is zero energy ontology (ZEO). Physical states are replaced by events, one might say. Event is a pair of states: initial state and final state. In ZEO these states correspond to states with opposite total conserved quantum numbers: positive and negative energy states. This guarantees that ZEO based quantum theory is consistent with the fundamental conservation laws and laws of physics as we understand them although it allows non-determinism and free will. Positive and negative energy states are localized at opposite boundaries of a causal diamond (CD). Penrose diagram - diamond symbol - is a good visualization and enough for getting the idea.

   State function CDreduction (SFR) is what happens in quantum measurement. The first SFR leads to a state which is one in a set of states determined once measurement is characterized. One can only predict the probabilities of various outcomes. Repeated quantum measurements leave the state as such. This is Zeno effect - watched kettle does not boil.

   In ZEO something new emerges. The SFR can be performed at *either* boundary of CD. SFR can occur several times at the same boundary so that the state at it does not change. The state at the opposite boundary however changes - one can speak of the analog of unitary time evolution - and the second boundary also moves farther away. CD therefore increases and the temporal distance between its tips does so also.

   The interpretation is as follows. The sequence of reductions at fixed bounary corresponds to a conscious entity, self. Self experiences the sequence of state function reductions as a flow of time. Sensory experience and thoughts, emotions, etc.. induced by it come from the moving boundary of CD. The constant unchanging part of self which meditators try to experience corresponds to the static boundary - the kettle that does not boil.

   Self dies in the *first* reduction to the opposite boundary of CD. Self however re-incarnates. The boundaries of self change their roles and the geometric time identified as distance between the tips of CD increases now in opposite direction. Time-reversed self is generated.

3. Negentropy Maximization Principle (NMP) stating roughly that the information content of consciousness is maximal. Weak form of NMP states that self has free will and can choose also non-maximal negentropy gain. The basic principle of ethics would be "Increase negentropy". p-Adic mathematics is needed to construct a measure for conscious information and the notion of negentropic entanglement (NE) emerges naturally as algebraic entanglement.

   The negentropy to which NMP refers is *not* the negative of thermodynamical entropy describing lack of information of outsider about state of system. This negentropy characterizes the conscious information assignable to negentropic entanglement (NE) characterized by algebraic entanglement coefficients with measure identified as a number theoretic variant of Shannon entropy. Hence NMP is consistent with the second law implied by the mere non-determinism of SFR.

   NMP demands that self during sequence of reductions at the same boundary generates maximum negentropy gain at the changing CD boundary. If self fails, it dies and re-incarnates (in a reduction to the opposite CD boundary more negentropy is generated). Selves do not want to die and usually they do not believe on re-incarnation, and therefore do their best to avoid what they see as a mere death. This is the origin of self-preservation. Self must collect negentropy somehow: gathering negentropic sub-selves (mental images) is a manner to achieve this. Plants achieve this by photosynthesis, which means generation of negentropy and storage of it to various biomolecules. Animals are not so saintly and simply eat plants and even other animals. We are negentropy thieves all.

   Re-incarnation also means increase of h_{eff} and getting to higher level in hierarchy and occurs unavoidably. As in England's theory, evolution occurs spontaneously: it is not climbing to Mount Everest but just dropping down.

4. England says "Some things we consider inanimate actually may already be 'alive'." This conforms with TGD view. Even elementary particles could have self: it is however not clear whether their

SFR sequences contain more that one reduction to a fixed boundary - necessary for having a sense about the flow of time. Elementary particles would even cognize: in adelic physics every system has both real and p-adic space-time surfaces as its correlates. It can even happen that system has only p-adic space-time correlates but not the real one: this kind of systems would be only imaginations of real system! This is one of the most fascinating implications of strong form of holography which follows from strong form of General Coordinate Invariance forced by the new view about space-time.

Clearly the notion of evolution generalizes from biological context to entire physics in TGD. One can speak about p-adic evolution and evolution as increase of h_{eff}. The most abstract formulation is number theoretical: evolution corresponds to the increase of the complexity of extension of rationals to which the parameters characterizing space-time surfaces belong to.

5. Does DDA emerge in TGD framework? NMP demands a lot of SFRs - also at the level of visible matter. The non-determimism of SFR alone means a loss of knowledge about the state of system and an increase of thermodynamical entropy so that living systems would generate entropy very effectively also in TGD Universe at the level of visible matter. If one believes that second law and NET imply DDA as England argues, then also TGD implies it at the level of visible matter. For dark matter the situation is different, since the outcome of SFR is not not random anymore. Seen from TGD perspective England's vision misses what is essential for life - the generation of phases of matter identifiable as the mysterious dark matter.

6. England talks about God. In a theory of consciousness predicting infinite self hierarchy, it is easy to assign the attribute "divine" to the levels of consciousness above given level of hierarchy. Personally I have nothing against calling the Entire Universe "God".

   One could give NMP the role of God. For strong form of NMP SFR would be almost deterministic except for ordinary matter for which entanglement is not algebraic and is therefore entropic: the universe would the best possible one in dark sectors and the worst one in the visible matter sector - Heaven and Hell! Weak form of NMP makes possible even more effective generation of negentropy than its strong form but allows self to make also stupid things and even SFRs with a vanishing negentropy gain: the outcome is state with no entanglement (system is in very literal sense alone in this state). The world in dark matter sectors is not anymore the best possible one but can become better and does so in statistical sense.

7. Replication is a crucial aspect of being alive. England argues that DDA allows to understand its emergence but does not tell about its mechanism. In TGD framework replication can be understood as an analog of particle decay - say photon emission by electron. This requires however a new notion: magnetic body. In Maxwell's theory one cannot assign any field identity to a physical system but TGD view about space-time forces to assign to a given system its field/magnetic body. The replication occurs primarily at the level of magnetic body carrying dark matter as large h_{eff} phases. Magnetic body replicates and ordinary visible matter self-organizates around the resulting copies of it. The dynamics of dark matter would induce also DNA replication, transcription and mRNA translation, and there are some indications that it is indeed "dark DNA" (dark proton sequences having DNA, RNA, amino-acids, and tRNA as biochemical counterparts), which determines what happens in transcription.

3 Could one apply the thermodynamical approach of England in TGD framework?

It turns out possible to gain amazing additional insights about TGD inspired view of life and consciousness by generalizing England's approach [1]. Several puzzling co-incidences find an explanation in the

thermodynamical framework and the vision about solar system as a living quantum coherent entity gains additional support.

1. The situation considered in England's approach is a system - say biomolecule - in heat bath so that energy is not conserved due the transfer of energy between reactants and heat bath.

2. The basic equation is equilibrium condition for the reaction $i \to f$ and its time reversal $f^* \to i^*$. The initial and final state can be almost anything allowing thermodynamical treatment: states of biomolecule or even gene and its mutation. The ratio of the rates for the reaction and its time reversal is given by the ratio of the Boltzmann weights in thermal equilibrium:

$$\frac{R(i \to f)}{R(f^* \to i^*)} = R \ , \qquad R = e^{-\frac{E_i - E_f}{T}} \ . \tag{3.1}$$

   E_i and E_f denote the energies of initial and final state. This formula is claimed to hold true even in non-equilibrium thermodynamics. It is important that the ratio of the rates does not depend at all on various coupling constant parameters. The equilibrium condition must be modified if initial and final states are fermions but it is assumed that states can be described as bosons. Note that in heat bath even fermion number need not be conserved.

3. If the energy eigenstates are degenerate, the ratio R of Boltzman factors must be modified to include the ratio of state degeneracies

$$R \to \frac{D(E_i)}{D(E_f)} \times e^{-\frac{E_i - E_f}{T}} \ . \tag{3.2}$$

   This generalization is essential in the sequel.

   One can imagine two possible reasons for the presence of exponentially large factors compensating Boltzmann weights $D(E_i)$. The first reason is that for $h_{eff} = n \times h$ the presence of n-fold degeneracy due to the n-fold covering of space-time surface reducing to 1-fold covering at its ends at the ends of CD is essential. Second possible reason is that the basic object are magnetic flux tubes modellable as strings with exponentially increasing density of states. These mechanisms could quite well be one and same.

Consider now the basic idea inspired by this formula in TGD framework.

1. Since magnetic flux tubes are key entities in TGD inspired quantum biology, stringy dynamics suggests itself strongly. The situation thus differs dramatically from the standard biochemical situation because of the presence of dark matter at magnetic flux tubes to which one can assign fermion carrying strings connecting partonic 2-surfaces defining correlates for particles in very general sense.

2. The key aspect of stringy dynamics is Hagedorn temperature [3, 2] (`http://rabiaaslam.weebly.com/uploads/7/1/4/3/7143240/stat_project.pdf`). Slightly below Hagedorn temperature the density of states factor, which increases exponentially, compensates for the Boltzmann factor. Hagedorn temperature is given by

$$T_{Hag} = \frac{\sqrt{6}}{2\pi} \frac{1}{\alpha'} \ , \tag{3.3}$$

where α' is string tension. In superstring models the value of string tension is huge but in TGD framework the situation is different. As a matter fact, the temperature can be rather small and even in the range of physiological temperatures.

3. What makes T_{Hag} so special is that in the equilibrium condition reaction and its reversal can have nearly the same rates. This could have profound consequences for life and even more - make it possible.

   In ZEO based quantum measurement theory and theory of consciousness time reversal indeed plays key role: self dies in state function reduction to the opposite boundary of CD and experiences re-incarnation as a time-reversed self. This process is essential element of memory, intentional action, and also remote metabolism, which all rely on negative energy signals travelling to geometric past assignable to time reversed sub-selves (mental images). The above formula suggests that intelligent life emerges near T_{Hag}, where the time reversed selves are generated with high rate so that system remembers and pre-cognizes geometric future as it sleeps so that memory planned action are possible.

4. String tension cannot be determined by Planck length as in string models if it is to be important in biology. This is indeed the case in TGD based quantum gravity. The gravitational interaction between partonic 2-surfaces is mediated by fermionic strings connecting them. If string tension were determined by Planck length, only gravitational bound states of size of order Planck length would be possible. The solution of the problem is that the string tension for gravitational flux tubes behaves like $1/h_{eff}^2$.

   In TGD framework string tension can be identified as an effective parameter in the expression of Kähler action as stringy action for preferred extremal strongly suggested by strong form of holography (SH) allowing the description of the situation in terms of fermionic strings and partonic 2-surfaces or in terms of interiors of space-time surfaces and Kähler action. $1/h_{eff}^2$ dependence can be derived from strong form of holography [9] assuming electric-magnetic duality for Kähler form, and using the fact that the monopoles associated with the ends have same magnetic and electric charges.

5. The discussion of the analog of Hawking radiation in TGD framework [9], [11] led to an amazing prediction: the TGD counterpart of Hawking temperature turns out to be in the case of proton very near to the physiological temperature if the big mass is solar mass. This suggests that the entire solar system should be regarded as quantum coherent living system. This is also suggested by the general vision about EEG [4]. Could Hawking temperature be near to the Hagedorn temperature but below it?

One can make this vision more detailed.

1. In ZEO the notion of heat bath requires that one considers reactants as subsystems. The basic mathematical entity is the density matrix obtained by tracing over entanglement with environment. The assumption that dark matter is in thermal equilibrium with ordinary matter can be made but is not absolutely crucial. The reactions transforming visible photons to dark photons should take care of the equilibrium. One could even assume that the description applies even in case of the negentropic entanglement since thermodynamical entropy is different from entanglement entropy negative for negentropic entanglement.

2. In TGD inspired quantum biology one identifies the gravitational Planck constant introduced by Nottale with $h_{eff} = n \times h$ [9, 6, 5, 10]. The idea is simple: as the strength of gravitational interaction becomes so strong that perturbation series fails to converge, a phase transition increasing the Planck constant takes place. $h_{gr} = GMm/v_0 = h_{eff} = n \times h$ implies that $v_0/c < 1$ becomes the parameter defining the perturbative expansion. h_{gr} is assigned with the flux tubes mediating gravitational interaction and one can say that gravitons propagate along them.

Note that this assumption makes sense for any interaction - say in the case of Coulomb interaction in heavy atoms: this assumption is indeed made in the model of leptohadrons [7] predicting particles colored excitations of leptons lighter the weak bosons: this leads to a contradiction with the decay widths of weak bosons unless the colored leptons are dark. They would be generated in the heavy ion collisions when the situation is critical for overcoming the Coulomb wall.

The cyclotron energy spectrum of dark particles at magnetic flux tubes is proportional to h_{gr}/m does not depend on particle mass being thus universal. In living matter cyclotron energies are assumed to be in the energy range of bio-photons and thus includes visible and UV energies and this gives a constraint on h_{gr} if one makes reasonable assumption about strengths of the magnetic fields at the flux tubes [8]. Bio-photons are assumed to be produced in the transformation of dark photons to ordinary photons. Also (gravitational) Compton length is independent on particle mass being equal to $L_{gr} = GM/v_0$: this is crucial for macrosopic quantum coherence at gravitational flux tubes.

3. The basic idea is that Hawking radiation in TGD sense is associated with all magnetic flux tubes mediating gravitational interaction between large mass M, say Sun, and small mass m of say elementary particle. How large m can be, must be left open. This leads to a generalization of Hawking temperature [11] assumed to make sense for all astrophysical objects at the flux tubes connecting them to external masses:

$$T_{GR} = \hbar \frac{GM}{R_S^2 2\pi} = \frac{\hbar}{8\pi GM} \quad . \tag{3.4}$$

For Sun with Schwartschild radius $r_S = 2GM = 3$ km one has $T_{GR} = 3.2 \times 10^{-11}$ eV.

Planck constant is replaced with $h_{gr} = GMm/v_0 = h_{eff} = n \times h$ in the defining formula for Hawking temperature. Since Hawking temperature is proportional to the surface gravity of blackhole, one must replace surface gravity with that at the surface of the astrophysical object with mass M so that radius $R_S = 2GM$ of the blackhole is replaced with the actual radius R of the astrophysical object in question. This gives

$$T_{Haw} = \frac{m}{8\pi v_0} (\frac{R_S}{R})^2 \quad . \tag{3.5}$$

The amazing outcome is that for proton the estimate for the resulting temperature for M the solar mass, is 300 K (27 C), somewhat below the room temperature crucial for life!

Could Hagedorn temperature correspond to the highest temperature in which life is possible - something like 313 K (40 C)? Could it be that the critical range of temperatures for life is defined by the interval $[T_{Haw}, T_{Hag}]$? This would require that T_{Haw} is somewhat smaller T_{Hag}. Note that Hawking temperature contains the velocity parameter v_0 as a control parameter so that Hawking temperature could be controllable. Of course, also $T_{Haw} = T_{Hag}$ can be considered. In this case the temperature of environment would be different from that of dark matter at flux tubes.

4. The condition $T_{Haw} \leq T_{Hag}$ allows to pose an upper bound on the value of the effective string tension

$$\frac{1}{\sqrt{\alpha'}} \geq \frac{m}{4\sqrt{6} v_0} \frac{R_S}{R} \quad . \tag{3.6}$$

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