Could one find a geometric realization for genetic and memetic codes?

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Abstract

The idea that that icosahedral structures assignable to water clusters could define a geometric representation of some kind of code is very intriguing. Genetic code is of course the code that comes first in mind. The observation that the number of faces of tetrahedron (icosahedron) is 4 (20) raises the question whether genetic code might have a geometric representation. In TGD framework also a second code emerges: I have christened it memetic code. Also memetic code could have a geometric realization. Another purely TGD-based notion is that of dark DNA allowing to assign the states of dark protons with DNA,RNA, tRNA and amino-acids and to predict correctly the numbers of DNA codons coding for a given amino-acid in vertebrate genetic code. A further element is the possibility of strong gravitation in TGD Universe meaning that space-time geometry and topology can be highly non-trivial even in condensed matter length scales. These ingredients allow to imagine geometric representations of genetic and memetic code.

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1 Introduction

Many-sheeted space-time makes possible large deviations from gravitation predicted by GRT, which in TGD framework can be seen as a description of gravitation at the long length scale limit. A fundamental distinction between GRT and TGD is that in TGD framework gravitational constant and cosmological constant - actually space-time dependent cosmological "constants" emerge as predictions of the theory rather than as fundamental constants of Nature.

For almost two decades ago I deduced by purely dimensional considerations a formula for gravitational constant G in terms of p-adic length scale and exponent of Kähler action for CP_2 type vacuum extremal defining the line of generalized Feynman diagram representing graviton [K5]. The prediction was that G should have an entire spectrum of values and approach p-adic length scale squared $L_p^2 = pR_{CP_2}^2$ when the action of the deformed CP_2 type vacuum extremal becomes small: this happens at short length scale limit. In particular, hadronic strings would correspond to strong gravitation limit, and TGD predicts fractally scaled up variants of ordinary hadron physics so that a rich spectrum of strong gravities follows as a prediction. This means that in TGD Universe the the gravitational effects on space-time geometry can be rather dramatic even in condensed matter length scales whereas in GRT the effects are extremely small. With this background philosophy I have discussed the possible differences between General Relativity and TGD-based view about gravitation in [K6]. This chapter should help also to understand the discussion of this section.

The starting point for the considerations of [K6] was the question whether the flat geometry for a piece of E^3 could be modified by gravitational effects so that it becomes a piece of S^3 allowing the decomposition of icosahedron to 20 regular tetrahedra (in E^3 geometry the tetrahedra cannot be regular). This kind of decomposition is actually possible for much more general deformations of E^3 geometry and one ends up with the vision about quasi-lattice like structures having piece of S^3 or hyperbolic space H^3 as a basic building brick. This notion makes sense in condensed matter length scales only if gravitational constant can be of order $G \sim L_p^2$ since Schwartschild radius $r_S = 2GM$ is the natural scale for the radius of S^3.

The cosmic honeycomb having voids with size of order 10^8 ly as basic building bricks is one possible quasi-lattice like structure suggested by these considerations. In condensed matter length scales strong gravitation could allow similar quasi-lattice like structures and icosahedral water clusters having tetrahedrons as building bricks could be examples of structures of this kind.

Cosmic honeycombs and their possible counterparts for water clusters modeled as consisting of icosahedral pieces of S^3 bring in mind foams (see `http://en.wikipedia.org/wiki/Foam`). Soap film foam is perhaps the most familiar example about foam. Plateau's laws (see `http://en.wikipedia.org/wiki/Plateau's_laws`) govern the structure of many foams. Mean curvature is constant for each film and physically derives from area minimization assuming constant pressure difference over the film. 3 films meet at angle of 120 degrees along a line known as Plateau border and 4 Plateau borders meet at each vertex at tetrahedral angle of $arcos(-1/3) \simeq 109.47$ degrees (tetrahedral angle is defined as the angle between radii drawn from the center of tetrahedron to its vertices). This suggests spherical tetrahedron as a basic building brick in a model as a honeycomb built from pieces of S^3. Plateau's laws can be derived mathematically for foams, for which films are minimal surfaces (pressure difference vanishes).

The idea that that icosahedral structures assignable to water clusters could define a geometric representation of some kind of code is very intriguing. Genetic code is of course the code that comes first in mind. The observation that the number of faces of tetrahedron (icosahedron) is 4 (20) raises the question whether genetic code might have a geometric representation and the following piece of text is inspired by this question. In TGD framework also a second code emerges: I have christened it memetic code [K3]. Also memetic code could have a geometric realization. Another purely TGD-based notion is that of dark DNA allowing to assign the states of dark protons with DNA,RNA, tRNA and amino-acids and to predict correctly the numbers of DNA codons coding for a given amino-acid in vertebrate genetic code [K4].

In the following some observations suggesting that this kind of geometric representation might exist are first discussed. After that a proposal for how genetic and memetic codes could be realized geometrically is considered.

2 The notions of memetic code and dark genetic code

Before going to the topic two TGD inspired concepts must be introduced, namely the notions of memetic code and dark genetic code. From the perspective of standard biology the talk about codes in plural might sound highly speculative. If one takes serious the analogy of living matter with a computing system, it becomes easier to imagine that genetic code could have generalizations and that these codes could have several representations just as computers use an almost unlimited number of different languages. Living matter would in this picture consist of sub-systems emulating each other just as ordinary computers do.

2.1 The notion of memetic code

The notion of memetic code introduced for more than 20 years ago allows to interpret the sequences of 21 DNA codons as memetic codons [K3]. The starting point is so called Combinatorial Hierarchy [A1].

Mersenne integers are defined as numbers $M_n = 2^n - 1$. For some values of n, which belong to a subset of primes, one obtains Mersenne primes. In particular the lowest members in the hierarchy defined by the recursive formula $M(n+1) = M_{M(n)}$ with $M(1) = 1$, one obtains the sequence $M(1) = 1$, $M(2) = 3$, $M(3) = 7$, $M(4) = 127$, $M(5) = 2^{127} - 1$, ... All the explicitly listed Mersenne integers $M(n)$, $n > 1$, are Mersenne primes. An unproven conjecture by Hilbert is that all numbers $M(n)$, $n > 1$ in the sequence are Mersenne primes.

What makes this sequence so interesting is that the $M(n) + 1$ as a power of 2 defines the number of elements for a Boolean algebra. One can say that in a structure with $M(n)$ elements one has thrown single element out from the Boolean algebra. This procedure is natural if Boolean algebra is represented as subsets of a set: the subset which is empty is not realizable physically and must be thrown out. One can say that Combinatorial Hierarchy corresponds to an abstraction hierarchy with levels consisting of statements, statements about statements, statements about.... The geometric analog of this hierarchy would be a fractal structure consisting of geometric objects consisting of points, geometric objects consisting of points replaced with geometric objects, ... Something like this one might expect in living systems.

Furthermore, in Boolean algebra each element has negation and only half of the elements can represent statements, which are simultaneously true. Therefore for a Boolean algebra with 2^n elements only 2^{n-1} elements can represent mutually consistent truths, "axioms". For the Combinatorial Hierarchy the numbers of "axioms" would be $1, 2, 4, 64, 2^{126}, ...$ At the third level one obtains the number 4 of DNA nucleotides, at the next level the number 64 of DNA codons, and at the next level one obtains the number $(2^6)^{21} = 2^{126}$ of DNA sequences obtained from 21 DNA codons. This led to the proposal that there might exist a hierarchy of analogs of the genetic code and that the highest physically realized code in the sequence could be "memetic code" assignable to M_{127}.

2.2 The notions of dark nucleus and dark genetic code

The notions of dark nucleus and dark genetic code belong to the most speculative ideas of TGD inspired quantum biology. The original motivation for the notion of dark proton came from the observations suggesting that in atto-second time scale 1/4:th of protons of water molecules are dark in the sense that are not visible in electron scattering and neutron diffraction [D2, D1, D3].

The proposed TGD-based interpretation is that the protons are dark in the sense of having large value of effective Planck constant assignable to their magnetic body [K4]. The varying fraction of dark protons could explain the rich spectrum of anomalous temperature and pressure dependences of many observables related to water.

A model for dark nucleons as consisting of 3 dark quarks leads to a completely unexpected connection with genetic code. One can group the states of the dark nucleon (proton) to groups such that these groups correspond to DNA, mRNA, tRNA, and amino-acids and there is a natural map realizing vertebrate genetic code in the sense that the numbers of dark DNA codons mapped to a given dark amino-acid is the same as for vertebrate genetic code.

The recent work of Persinger's group [J1, J2, J3] combined with the observation of Hu and Wu [J4] that the magnetic interaction energy between protons assigned to the opposite sides of cell membrane corresponds to frequency in EEG range led to the conjecture that the pair of cell membrane lipid layers is accompanied by a pair of dark proton strings analogous to DNA double strand and indeed representing double DNA strand. There is also a close connection with the model of DNA as topological quantum computer [K2]: in this model magnetic flux tubes connecting nucleotide with lipids are responsible for braiding defining the quantum computer programs.

3 Some speculative questions

In the following some speculative questions about geometric representations of genetic code and memetic code are raised.

3.1 Could the faces of tetrahedron correspond to the four DNA nucleotides?

Consider first the intriguing observations suggesting that tetrahedral and icosahedral geometries relate to genetic code and its generalization to memetic code [K3]

1. The opening solid angle for each of the 20 tetrahedrons in S^3 icosahedron is $\Psi = 4\pi/20$. On the other hand, in DNA strand this angle corresponds in a good approximation to the twist angle for a single nucleotide from the fact that 30 DNA nucleotides (10 codons corresponds to twist angle of 6π (and to a length of 10 nm for DNA strand). For twist angle of 2π the number of nucleotides is not divisible by 3 (integer number of codons). This could be seen as a hint that S^3 icosahedral water clusters are biologically important.

2. Tetrahedron has 4 faces. Could they somehow correspond to the 4 DNA nucleotide? In order to distinguish between codons one must be able to distinguish between the faces of the tetrahedra - mark them - , to assign to given face a unique DNA, and to select one of the faces of tetrahedron - to "activate" it. In the case of DNA double strand this could mean that two of the faces of a given tetrahedron are glued to the predecessor and successor of the nucleotide in the DNA strand. The third face would be paired with conjugate strand by hydrogen bonds so that one open face would remain and would represent DNA nucleotide.

   The marking of the faces of the S^3 tetrahedron would require a breaking of $SO(3)$ symmetry. Symmetry breaking could take place when one looks the tetrahedron in E^3 geometry. One could say that $SO(4)$ symmetry of S^3 geometry breaks the $SO(3) \times T^3$ symmetry of E^3 (emergence of high space-time symmetry is not consistent with high imbedding space symmetry). For instance, the faces of the tetrahedron could have different areas in E^3 metric. The breaking of symmetries could be due to the shift of the S^3 tetrahedron from North Pole of S^3 to some other point, and due to the breaking of translational invariance of E^3 for S^3 tetrahedron. The external face of an icosahedral tetrahedron can be distinguished from the other three faces which are internal even without the breaking of $SO(3)$ symmetry (only breaking of $SO(4)$ symmetry of S^3) .

3.2 Could the 20 outer faces/tetrahedrons of the icosahedron correspond to amino-acids?

S^3 icosahedron has 20 faces. Could they somehow correspond to 20 different amino-acids? To achieve this two conditions must be satisfied.

1. One must be able to distinguish between the outer faces of the icosahedron so that one can associate to a given face only single amino-acid. As already explained, symmetry breaking allowing to distinguish between the faces is possible in E^3 geometry if the S^3 icosahedron is moved from the origin of S^3 to some other point.

   For instance, the areas of the faces could be different and if the amino-acid is glued only to the face which it "fits" (recall the analogy with lock and key mechanism) one would have the desired 1-1 correspondence with amino-acids and icosahedrons. The outcome could be that only single amino-acid can be glued to a given face. Note that magnetic flux tubes could realize the correspondence between amino-acids and icosahedral outer faces in very concrete manner: this mechanism is proposed as a general mechanism of bio-catalysis making it possible for two reacting molecules to find each other in the thick molecular soup [K2, K1].

2. One must also be able to "activate" a given face, perhaps by gluing something to it. This "something" could be amino-acid but also something else, say additional tetrahedron representing a genetic codon.

Dark DNA codon corresponds to dark proton identified as 3-quark state. Could this 3-quark state have a geometric representation? The decomposition of icosahedral surface to triangles suggests that triangle is a natural geometric object for DNA, and in the sequel a geometric model for dark DNA codons based on a repeated division of equilateral triangle to equilateral triangles is considered. One must however keep in mind that this kind of representation might not be necessary. It is enough to assume single dark proton per each tetrahedral building brick of icosahedron. Dark protons would in turn be connected to nuclear string.

3.3 Icosahedral realization of the memetic code?

In the presence of symmetry breaking allowing to distinguish between the 20 icosahedral tetrahedrons the external faces of the icosahedron can be in 1-1 correspondence with amino-acids. One can consider even more ambitious option. The icosahedron + tetrahedron structures with 20 icosahedral tetrahedrons plus 1 tetrahedron glued to some icosahedral face could be perhaps interpreted as memetic codons if each tetrahedron represents a genetic codon. A crucially important constraint is that the icosahedral tetrahedrons have a unique linear ordering.

These memetic codons could be also associated with real amino-acids if a given amino-acid can attach only to single face of the icosahedron and there is a mechanism which selects which face is "active". This particular amino-acid would be naturally coded by the 21^{st} DNA codon at the surface of the icosahedron so that one would kill to flies with single blow obtaining both the a representation of memetic codons and assign to the 21^{st} DNA codon corresponding amino-acid. If so, water clusters could represent immense amount of dark biological information.

How could one realize dark memetic codons as dark nuclei? The obvious possibility is as strings of 21 dark protons: in this case the linear ordering of protons would be essential for the realization of the code. A realization inspired by the conventional nuclear physics framework leads naturally to the icosahedral structure.

1. A nucleus carrying 20 protons or neutrons is a magic nucleus (exceptionally stable). For instance, the biologically important ion Ca^{++} corresponds to double magic nucleus has 20 protons and 20 neutrons. Also neutrons are present in ordinary nuclei, and I have proposed that protons and neutrons could correspond to different space-time sheets: perhaps these space-time sheets could correspond to Northern and Southern hemispheres of S^3.

2. The information about the ordering of dark nucleons is not lost if icosahedral nucleus + single proton is obtained by a convolution of a dark proton nuclear string. The icosahedral core of S^3 icosahedral dark nucleus consisting of 20 dark protonic tetrahedra would be magic and analogous to a closed shell of an atom.

   From the net representation (see `http://en.wikipedia.org/wiki/File:Icosahedron_flat.svg`) of icosahedron obtained by cutting the icosahedron open, it is clear that there are at least two paths of this kind but differing only by orientation. Each of them can be regarded as a union of 5 4-triangle paths of the net combining to form a connected triangle path at the surface of icosahedron when appropriate identifications of the edges are made. The step between neighboring triangles corresponds to reflecting with respect to the common edge. Each 4-triangle path corresponds to a path containing vertices of "big" tedrahedron (not one of the twenty tetrahedrons with one vertex at the center of icosahedron) shared also by icosahedron. This sequence corresponds to the orbit of the icosahedral isometry group, which is the alternating group A_5 (60 even permutations of 5 letters) acting transitively so that the orbit visits all triangles at the isosahedral surface. A good guess is that these two oppositely oriented orbits and their images under A_5 define the only manners to fill the icosahedral surface by single path. The number of images is 12 since each of the 12 vertices of icosahedron defines one tetrahedron. Note that this identification for the folded DNA sequence allows also to think that it traverses the surface of the icosahedron rather than filling the entire icosahedron.

3. In chemistry valence electrons dictate the chemistry and in complete analogy with this the 21^{st} dark proton at the surface of the icosahedron would code for the amino-acid attached to it. This icosahedral folding of the nuclear string would be analogous to the folding of protein to a globular shape in its resting state. This folding could indeed characterize the resting state of dark DNA and when dark DNA becomes active - say during a transcription like process - unfolding would occur. Similar unfolding takes place also for the ordinary DNA.

If each icosahedral tetrahedron corresponds to one particular amino-acid, one can argue that a given tetrahedron can be associated only to those DNA codons which code the amino-acid associated with the tetrahedron. As following arguments show, this correspondence leads to problems.

1. If the genetic code dictates the correspondence between tetrahedra and DNA codons, then the three stopping sign codons cannot be contained by the memetic codons so that memetic code would not be fully realised.

2. The allowed memetic codons would code for sequence of 20 different amino-acids and there would be strong correlations between neighboring amino-acids in the sequence since the DNA sequence

would define a non-self-intersection path visiting every triangle at the surface of the icosahedron only once, and a given amino-adic would have as edge neighbors only three amino-acids. If only single sequence is possible as proposed above, then only single amino-adic sequence containing all amino-acids would be allowed and the number of memetic codons coding for it would be product of numbers of codons coding for the 20 amino-acids.

3.4 Geometric representation of dark DNA codons

Could one have a concrete geometric representation for DNA codons and nucleotides in the proposed model? The fact that dark DNA codon consisting of 3 quarks corresponds to triangle (or corresponding icosahedral tetrahedron) is highly suggestive.

1. Icosahedral surface triangle would naturally correspond to a triplet defining DNA codon and the vertices of the triangle to the letters A, T, C, G. This could be achieved geometrically by dividing a given icosahedral surface triangle, call it T, to 4 equilateral triangles T_i, $i = 1, 2, 3, 4$ and assigning the three letters of the codon to the resulting three triangles T_i , $i = 1, 2, 3$, sharing a vertex with T. The inner triangle T_4 would remain unpopulated.

2. How to represent codon geometrically for T and perhaps also the letter A, T, C, G for T_i? One manner to achieve the latter goal is to divide T_i to further equilateral triangles T_{ij}, $j = 1, 2, 3, 4$ and assign A, T, C, G to T_i by some kind of symmetry breaking distinguishing between them geometrically. The dark codon consisting of 3 quarks could select somehow this triangle. The simplest possibility is that the spatial wave function of i^{th} quark of proton is located inside one T_{ij}, $i = 1, 2, 3,\ j = 1, 2, 3, 4$. The connection with quark model of nucleon would be that the quarks are at the vertices of triangle T_i and are connected to the centre of T_i by color flux tubes. Inside T_i the location of quark is inside T_{ij}. An alternative option is that quarks are connected by color flux tubes directly to each other.

A couple of remarks are in order.

1. The model for dark DNA does *not* allow to represent the counterparts of DNA codons as un-entangled products of 3-quark states: the states are quantum superpositions of 3-quark states and the decomposition of codon to letters is not possible. This means that DNA codons are "irreducible". One can however deduce correspondence between codons and amino-acids and it corresponds to the vertebrate genetic code. The geometric representation for the codons as mapping of DNA codons to geometric objects however still make sense if the positions of quarks obey the above rule for a given entangled quark triplet.

2. The model for dark DNA [K4] assumes that dark DNA strand is linear so that symmetry breaking of rotational symmetry to SO(2) consisting of rotations around the strand takes place. In the recent situation similar breaking of symmetry must take place and the natural axis is no the axes defined by the normal of the triangle defining dark DNA codon.

3. One can also wonder what might be the geometric counterparts of dark mRNA, tRNA, and amino-acids.

3.5 Could water clusters represent memetic code?

Could the dark protons realizing dark genetic codons as nuclear strings be associated with water molecules or clusters of them? One can imagine two alternative realizations of the icosahedral memetic codons.

1. It is known that water molecules themselves have tetrahedral structure with 2 lone electron pairs and H_+ nuclei are at the vertices of the tetrahedron (maybe regular S^3 tetrahedron). There is chemical symmetry breaking since the faces come in two types: 2 faces of type $H_+H_+(2e)$ and 2 faces of type $H_+(2e)(2e)$. If the second proton is of the water molecule is dark, a further symmetry breaking takes place and one has faces of 3 types. The symmetry of $H_+H_+(2e)$ faces could be broken if they correspond the two lone electron pairs are located the center of

icosahedron and it surface. The chemical symmetry breaking and perhaps also magnetic flux tubes would help to assign to unique amino-acid to one of the tetrahedrons.

Icosahedron would consists of a folded linear sequence of tetrahedral water molecules - formed perhaps perhaps by hydrogen bonding. The representation of memetic codon as a single icosahedral cluster of 21 water molecules would predict single dark proton per water molecule. Recall that the average in atto-second time scale would be 1/4 dark protons per water molecule. I do not know whether icosahedral clusters of this kind exist.

2. It is however known that known (see `http://www.lsbu.ac.uk/water/clusters.html`) that 14 water molecules indeed combine to form tetrahedral structures (see `http://www.lsbu.ac.uk/water/clusters.html#tetra` [?]condwater1, and that these in turn combine to form icosahedral structures. The size scale of the 14 molecule cluster is nearer to the size scale of single DNA nucleotide so that perhaps this option is more realistic. If these structures provide a representation of memetic codons with tetrahedral structure of 14 water molecules representing single DNA codon or amino-acid, there are 14 water molecules per single dark proton representing dark DNA codon.

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