How to compose beautiful music of light in bio-harmony?

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Abstract

TGD leads to a notion of bio-harmony in terms of icosahedral and tetrahedral geometries and 3-chords made of light assigned to the triangular faces of icosahedron and tetrahedron Bio-harmonies are associated with the so-called Hamiltonian cycles , which go through every vertex of Platonic solid once. For icosahedron the number of vertices is 12, the number of notes in 12-note scale. The 64 codons of bio-harmony represented as light 3-chords formed by dark photon triplets are formed from 3 20-chord harmonies associated with icosahedron and the unique 4-chord harmony associated with tetrahedron.

The surprise was that vertebrate genetic code emerged as a prediction: the numbers of DNA codons coding for a given amino acid are predicted correctly. DNA codons correspond to triangular faces and the orbit of a given triangle under the symmetries of the bio-harmony in question corresponds to DNA codons coding for the amino acid assigned with the orbit.

Codon corresponds to 6 bits: this is information in the usual computational sense. Bio-harmony codes for mood: emotional information related to emotional intelligence as ability to get to the same mood allowing to receive this information. Bio-harmony would be a fundamental representation of information realized already at molecular level and speech, hearing and other expressions of information would be based on it.

One topic of this article is the detailed definition of the notion of bio-harmony. A sequence of 3-chords of bio-harmony defines a music piece: what rules guarantee that this piece is beautiful? This question is interesting because the chords of bio-harmony correspond to DNA codons. One can also wonder whether the standard rather simple harmonies can be understood. Also the role of tetrahedral harmony and its relation to start and stop codons is interesting.

1 Introduction

The topic of this article is the detailed definition of the notion of bio-harmony [L2, L3, L9]. A sequence of 3-chords of bio-harmony defines a music piece: what rules guarantee that this piece is beautiful? This question is interesting because the chords of bio-harmony correspond to DNA codons.

1.1 Bio-harmony as a realization of genetic code

TGD leads to a notion of bio-harmony in terms of icosahedral and tetrahedral geometries and 3-chords made of light assigned to the triangular faces of icosahedron and tetrahedron [L2, L3, L9]. Bio-harmonies are associated with the so-called Hamiltonian cycles , which go through every vertex of Platonic solid once. For icosahedron the number of vertices is 12, the number of notes in 12-note scale. The 64 codons of bio-harmony represented as light 3-chords formed by dark photon triplets are formed from 3 20-chord harmonies associated with icosahedron and the unique 4-chord harmony associated with tetrahedron.

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Codon corresponds to 6 bits: this is information in the usual computational sense. Bio-harmony codes for mood: emotional information related to emotional intelligence as ability to get to the same mood allowing to receive this information. Bio-harmony would be a fundamental representation of information realized already at molecular level and speech, hearing and other expressions of information would be based on it. For emotional expression at RNA level possibly involved with conditioning at synaptic level see [L6].

1.2 About generalizations of the notion of bio-harmony

One can consider several generalizations for the notion of bio-harmony.

1. All Platonic solids, in particualr tetrahedron, cube, octahedron and dodecahedron are possible and one can consider the possibility that they also define harmonies in terms of Hamiltonian cycles. Dodecahedron would have 5-chords (pentagons as faces) as basic chords and there is only single harmony. Same mood always, very eastern and enlightened as also the fact that scale would have 20 notes.

   Also octahedron gives 3-chords (triangular faces) whereas cube gives 4-chords (squares as faces). One can of course speculate with the idea that DNA could also represent this kind of harmonies: sometimes the 3N rule is indeed broken, for instance for introns.

2. Galois confinement [L10] allows the possibility to interpret dark genes as sequences of N dark proton triplets as higher level structures behaving like a single quantal unit. This would be true also for the corresponding dark photon sequences consisting of 3N dark photons representing the gene in bio-harmony as an analog of a music piece consisting of 3-chords and played by transcribing it to mRNA.

   Basic biomolecules (DNA, RNA, tRNA, amino acids) would have names represented as a sequence of light 3-chords representing a piece of music and dark biomolecules with the same name could recognize and communicate with each other in 3N-resonance. Dark-ordinary communications could transform dark 3N-photon to single bio-photon so that resonance would be possible when the sum of energies coincides with a transition energy of the ordinary biomolecule. The resonance condition would very effectively select survivors in the fight for survival.

3. The picture can be viewed even more generally. Any discrete structure, defining graph, in particular cognitive representation providing a unique finite discretization of space-time surface as points with the coordinates of the 8-D imbedding space coordinates in the extension of rationals, defines harmonies in terms of Hamiltonian cycles. Could also these harmonies

make sense? The restrictions of the cognitive representations to 2-D partonic 2-surfaces would define something analogous to bio-harmony as Hamiltonian cycle of 2-D graph (Platonic surfaces solids can be regarded as 2-D graphs). The interpretation as representations of Galois groups and the notion of Galois confinement is possible although one loses the symmetries of the Platonic solids allowing to identify genetic code.

During years I have indeed considered some modifications of the original bio-harmony base on the fusion of 3 icosahedral harmonies and tetrahedral harmony in partcular so called E_8 harmony and toric harmony [L4, L5] but the overall conclusion [L8] is that the original model is the most plausible candidate.

1.3 The challenges of the model

The model of bio-harmony is far from complete and this article discusses a more detailed definition. Also the question about the rules defining beautiful music by posing rules on chord sequences are considered. These aesthetic rules are also rules for the corresponding DNA and amino-acid sequences.

1. The fusion of the three harmonies having symmetry groups Z_n, $n = 6, 4, 2$ has been considered but not in the required detail. The Hamiltonian cycles of icosahedron are fixed only modulo isometries of icosahedron preserving the shape of the cycle, scalings of the cycle by a power of quint forming group Z_{12} leaving the cycle of invariant but inducings transponation (change of the key), and the change of the cycle orientation possibly related to minor-major dichotomy correlating with joyful-sad dichotomy. For a single icosahedral cycle these transformations do not change anything but for the fusion of 3 cycles realized at the same icosahedron the situation changes, and the number of harmonies increases dramatically.

   Are all combinations of icosahedral harmonies allowed or are there some natural restrictions on them? I have considered this question but it seems that there is no good reason for posing any restrictions. The spectrum of harmonies determined by dark genetic codons and therefore the spectrum of emotions at the molecular level would be surprisingly rich.

2. Is it possible to reproduce the basic harmonies of the western music based on the 12-note system which inspired icosahedral harmonies? In particular, can one understand the chords C, F, G of C-major scale? By octave equivalence the nearest neighbors of the Hamiltonian cycle are related by quint scaling scaling frequency by factor 3/2 scaling C to G. The 3-chords containing at least one cycle edge contain quint (C→ G) and quint is the basic aspect of bio-harmony. For harmonies with opposite orientation quints become perfect fourths (C→ F) and FCG corresponds to transponantion of F by two quints.

   For a single icosahedral harmony the chord-pairs analogous to C-F or C-G do not appear in any obvious manner. If the 3 icosahedral harmonies are related by quint scalings (FCG) the analogs of these chord pairs become natural. Could this be the solution to the problem?

3. What are the rules producing aesthetically satisfying music? I experimented with the ultraconservative assumption that only chord pairs containing common quint are allowed: the result was not ugly but it was boring. Already the transitions of CFG major scale are too radical for this option!

   An attractive idea is that the sequence of 3-chords is continuous in some sense. Could the sense be strictly geometric: could chord pairs be nearest neighbors in some sense. For Option I nearest neighbors have a common edge (3 nearest neighbours). For Option II they have a common vertex (10 nearest neighbors). These options do not allow all 3-chord pairs and thus not all possible DNA pairs and all possible amino-acid pairs. A more abstract definition identifies the nearest neighbors with the orbits of nearest neighbors for Option I or II under the symmetry group Z_n ($n = 6, 2$). Codon is replaced with the codons coding for the same amino-acid. For Option II this allows to have all possible chord pairs and therefore DNA and amino-acid pairs.

4. Also the role of tetrahedral harmony and its relation to start and stop codons is interesting. One wants also to understand why the genetic code at the bio-chemical level is not quite complete and why there are several variants of it.

Symmetry	$\#(class)$	$\#(repr)$
Z_6	1	8
Z_4	2	12
$Z_{2,rot}$	3	24
$Z_{2,refl}$	5	24

Table 1: The number $\#(class)$ of equivalence classes of Hamiltonian cycles ad the number $\#(repr)$ of representatives in the class for icosahedral Hamiltonian cycles. If the orientation is not taken into account the number of representatives reduces to $\#(repr)/2$

2 About bio-harmonies

The set of allowed 3-chords define music harmony. The 12-note scale is essential for the western view about harmony. The TGD inspired geometric model for music harmony identifies bio-harmony as a fusion of 3 icosahedral harmonies with 12-note scale represented geometrically as a Hamiltonian cycle at icosahedron and 1 tetrahedral harmony represented as a unique Hamiltonian cycle of tetrahedron. Each icosahedral harmony has 20 3-chords identifiable as triangular faces of the icosahedron whereas tetrahedral harmony 4 3-chords. This gives 20+20+20+4=64 chords - the number of genetic codons.

2.1 Symmetries of icosahedral harmonies

There are 3 types of icosahedral harmonies with symmetries characterized by a subgroup of icosahedral isometries, which is Z_6, Z_4 or Z_2 acting either as a rotation by π or as a reflection. The orbits of triangles are identified as counterparts of amino-acids coded by the DNA codons assigned with the triangles of the orbit.

1. For Z_6 given triangle gives rise to 3 6-orbits with 6 triangles and 1 2-orbit: Z_3 subgroup of icosahedral group permutes the 3 6-orbits and acts trivially to 2-orbit.

2. For Z_4 there are 5 4-orbits and Z_5 permutes these orbits.

3. For Z_2 there are 10 2-orbits and Z_{10} permutes them. Z_2 can act either as reflections or rotations.

There are also 6 cycles without any symmetries perhaps identifiable as dis-harmonies. They will not be considered in the sequel. For them the number of amino-acids coded by codon would be one.

Table 1 summarizes the numbers of equivalence classes of cycles and under icosahedral rotation group for various symmetry groups as well as the numbers of representatives in the class. These numbers allow to deduce the number of bio-harmonies by fixing one of the icosahedral harmonies, most naturally the Z_6 harmony for which one has only one class.

Remarkably, the combination of 3 icosahedral cycles with symmetries Z_k, $k = 6, 4, 2$ with the tetrahedral Hamiltonian cycle gives 64 codons and the model correctly predicts the numbers of DNA codons coding for a given amino acid. Could there be a connection between music and genetic code? Could one speak of bio harmonies as correlates of emotions at the molecular level?

The natural expectation is that the symmetries Z_n of a given harmony leave the ratios of frequencies of 3-chords invariant. This is true if the edge connecting nearest neighbors along Hamiltonan cycle corresponds to a quint that is scaling of frequency by 3/2 and projection to the basic octave (octave equivalence). Therefore the chords at the orbit of a given chord coding for the same amino-acid are replaced by a scaling by power of 3/2 so that the scalings are mapped to unitary rotations.

The factors of 12 include indeed 6, 4, and 2 so that the 12-element group of scalings modulo octave equivalence can be mapped to Z_{12} rotations. There is however a problem with rational quints due to the fact that - as already Pythagoras found - $(3/2)^{12} = 129.746...$ does not correspond exactly to $2^7 = 128$. One reason for introducing icosahedron could be that this brings additional

note allowing to get rid of the problem. One can also construct the notes by powers of $2^{1/12}$ applied to the basic frequency but now the frequencies are not rational. Furthermore, people with absolute pitch favor rational frequency ratios, which suggests that rational numbers and roots of unitary assignable with adelic physics as physics of cognition are really important.

2.2 Fusion of 3 icosahedral harmonies and tetrahedral harmony to bio-harmony

There is quite a large number of icosahedral Hamiltonian cycles and therefore of bio-harmonies. Although the isometries of icosahedron and their transponations do not matter for given icosahedral harmony, they matter when one has 3 icosahedral harmonies. A simple example from physics helps to understand this: although rotations are symmetries of an N-particle system the rotations of a single particle are not symmetries anymore and represent new degrees of freedom.

1. Bio-harmony assigns to the same icosahedron 3 Hamilton cycles with symmetries Z_k, $k = 6, 4, 2$. This means assigning to the same icosahedron 3 Hamiltonian cycles giving rise to 3 representations of 12-note scale each giving 20 chords so that one 20+20+20 chords coding 3 classes of amino acids. Tetrahedron gives the remaining 4 chords.

   There are N_i, $i = 1, 2, 3$ cycles corresponding to $Z_{k(i)}$, $k(i) = 6, 4, 2$: for the values of N_i and detailed 3-chord contents of icosahedral harmonies see [L1]. From the table **Table 1** one has for $(Z_6, Z_4, Z_{2,rot})$ $\#(class) = (\#(class)_1, \#(class)_2, \#(class)_3) = (1, 2, 3)$ giving 6 different classes and $(Z_6, Z_4, Z_{2,refl})$ $(\#(class)_1, \#(class)_2, \#(class)_3) = (1, 2, 5)$ giving 8 different classes. This gives $N = 14$ different icosahedral Hamiltonian cycles.

   The numbers of reresentatives for given equivalence class are for both $(Z_6, Z_4, Z_{2,rot})$ $(Z_6, Z_4, Z_{2,rot})$ $\#(repr) = (2, 12, 24)$.

2. The 3 cycles go through all points of the icosahedron. This means that for each point of icosahedron there are 3 cycles going through that point. There can be however situations in which there are common edges. 5 edges arrive at given icosahedral vertex. There are 3 cycles entering and leaving the vertex: this makes 6 cycle edges. There is necessarily one edge shared by two cycles. If the edge is shared by 3 cycle edges, one edge has no cycle edge. This kind of situation - 3-edge - is achieved by performing a suitable Z_5 rotation for the third cycle.

   Do all bioharmonies have 3-edges? Could 3-edges have a special role concerning bio-harmony and music experience? Could they define chords with preferred quints such as chords C, F, G in C major scale? The bio-harmonies having chord(s) with 3-edge could give rise to simple CFG type harmonies. Fusion of 3 icosahedral harmonies differing by quint scalings gives a CFG type situation, and one could assign all these 3 types of chords with a triangle with 3-edge. Geometrically the chord progression would reduce to a repetition of the same triangle! Allowing also the triangle at the other side of the 3-edge, the chord progression involving only these 2 triangles consists of 3+3=6 chords.

3. One can assume that the 3 Hamiltonian cycles start at the same almost arbitrarily chosen vertex of the icosahedron. As a special case one can assume that it corresponds to the same basic note (C). Since Z_6 allows only a single cycle, it is natural to fix it: the fact this cycle has 2 orientations gives degeneracy factor 2.

   The other other cycles are determined apart from the rotation group Z_5 leaving the base point invariant. Therefore the Z_4 and Z_2 harmonies give rise to an additional $5^2 = 25$-fold degeneracy of bio-harmonies $N \to 25N$. If the cycles are required to have a common first edge besides the base point, one does not obtain the degeneracy factor. This argument shows that common edges are possible and the vertices associated with them are definitely special.

   Fixing the cycle types and the Z_6 cycle one can calculate the number of bioharmonies for a given equivalence classes as the number $\#(repr(Z_4)\#(repr(Z_2)$ One obtains 12×24 representatives for both choices of Z_2. For r $Z_2 = Z_{rot}$ the total number of bioharmonies is

$$N(harmony, rot) = 2 \times 2 \times 12 \times 3 \times 24 = 2^7 \times 3^2$$

$$N(harmony, refl) = 2 \times 2 \times 12 \times 5 \times 24 = 2^7 \times 3 \times 5 \ .$$

The first factor of 2 comes from the two orientations for the fixed Z_6 cycle.

4. The transponations realized as scalings along the Hamiltonian cycle define 1-to-1 map of icosahedral vertices which is however not an isometry but preserves the harmony. This gives a degeneracy factor 12^2 and one has

$$N(harmony, ...) \to 12^2 \times N(harmony, ...) \ .$$

The formula for the total number of bioharmonies is

$$\begin{aligned} N(harmony) &= N(harmony, rot) + N(harmony, refl) = 2^{14} \times 3^3 \ , \\ N(harmony, rot) &= 2^{11} \times 3^4 \ , \\ N(harmony, refl) &= 2^{11} \times 3^3 \times 5 \ . \end{aligned} \tag{2.1}$$

(2.2)

2.3 How to understand the tetrahedral code and symmetry breaking of the perfect code?

The precise understanding of the relationship between tetrahedral and icosahedral codes has been a long standing challenge andI have considered several scenarios. The geometric idea has been that tetrahedron is somehow glued to icosahedron along on faceand selects a unique codon of the icosahedron defining the basic chord. As found, another manner to fix this chord as a chord to which one can assign 3 cycle edges. There might be other faces with the same property.

One can get information about the situation by looking at the code table.

1. There are 10 unbroken icosahedral Z_2 doublets containing (stop,stop) plus 1 symmetry broken doublet (stop,tyr). What could cause the symmetry breaking? The energy resonance condition associated with the pairing of dark mRNA codons with dark tRNA codons could explain the presence of stop codons: translation would stop when no tRNA in energy resonance is found.

   Dark 3-photon representing the dark stop codons could not couple to tRNA codon in energy resonance since there would not be tRNA with cyclotron resonance energy triplet resonating with that of dark stop codon. This would be the case for the (punc,punc) doublet and also for punc member of (puc,trp) doublet. The mimicry of dark level by biochemical level would not be complete. For the variants of the code it would be even less complete.

2. From the table one learns that both Z_6 and Z_4 codons are realized completely for the vertebrate code. This leaves only one conclusion: (ile,ile,ile,met) must correspond to a Z^4 symmetry breaking for tetrahedral rather than icosahedral 4-plet. The AGG coding for met, which is unique in the sense that it serves as a mark for the beginning of genes, would correspond to a tetrahedral face.

   The failure of energy resonance could force the splitting of unbroken tetrahedral ile 4-plet to (ile,ile,ile,met). Fourth codon in Z_4 4-plet would be in energy resonance with tRNA associated with met. Note that icosahedral code gives rise to 4+5+10=19 amino-acids and met provides the 20^{th} amino acid. Symmetry breaking would be necessary to mark the starting and stopping points of transcriptionand translation.

   3-chords also depend on the icosahedral harmony and for some icosahedral harmonies energy resonance could fail so that the emotional state of at dark matter level would reflect itself at the biochemical level. The number of icosahedral harmonies is (1,2,3,5) for $(Z_6, Z_4, Z_{rot,}, Z_{2,refl})$. For Z_4 and Z_2 the failure of energy resonance is possible.

   Remark: I must confess that many earlier texts about the problem contain a stupid error. I have considered the proposal that (ile,ile,ile,met) could correspond to symmetry

broken icosahedral 4-plet. Vertebrate code has however 5 unbroken 4-plets corresponding to (val,pro,thr,ala,gly) as also 3 unbroken 6-plets (leu,ser,arg)! For vertebrate code the symmetry breaking can therefore occur only for icosahedral Z_2 doublets and tetrahedral Z_4 4-plet.

2.4 Variations of the genetic code

There exists also as many as 31 genetic codes (see `http://tinyurl.com/ydeeyhjl`) and an interesting question is whether this relates to the context dependence. Mitochondrial codes differfrom the nuclear code and there are several of them. The codes for viruses, prokaryotes, mitochondria and chloroplasts deviate from the standard code. As a rule, the non-standard codes break U-C or A-G symmetries for the third code letter.

In the proposed framework the failure of energy resonance conditions could be at the level of tRNA. The dark tRNA analog of RNA could be in energy resonance with "wrong" amino acid.

Some examples are in order (see `http://tinyurl.com/puw82x8`).

1. UUU can code Leu instead of Phe (symmetry breaks for Phe doublet) and CUG can code Ser rather than Leu (symmetry breaks for leu 6-plet). In this case itseems that the "problem" is at the level of tRNA. The dark RNA codon could couple with a "wrong" amino acid.

2. In bacteria the GUG and UUG coding for Val and Leu normally can serve as Start codons. In this case symmetry breaking for Z_4 4-plet would be in question. The problem could be also at tRNA level. Note however that both tetrahedral codons and icosahedral Z_4 codons have the same symmetry group. Could tetrahedral codons correspond to a different frequency scale and correspond to Leu and Val 4-plet instead of symmetry broken ile 4-plet.

3. UGA can code to trp rather than punc: in this case the broken symmetry would be restored since also UGG codes for trp. Both codons for (trp,trp) doublet would be in resonance: this supports the explanation for the emergence of the third stop codon.

4. There is variation even in human mitochondrial code (see `http://tinyurl.com/puw82x8`). In 2016, researchers studying the translation of malate dehydrogenase found that in about 4 per cent of the mRNAs encoding this enzyme the UAG Stop codon is naturally used to encode the AAs trp and arg. This phenomenon is known as Stop codon readthrough [I1]. Also this phenomenon could be understood at tRNA level.

5. There is also a variant of genetic code in which there are 21st and 22nd AAs Sec and Pyl coded by Stop codons. UGA in (punc,trp) doublet can code for Sec and punc in the same organism. UAG can code for (punc,punc) doublet Pyl instead of punc and UAG. This introduces additional breaking of A-G symmetry for the third letter of codon. Energy resonance at the level of tRNA could explain these deviations from the vertebrate code.

Peter Gariaev has introduced the notion of homonymy of genetic code meaning that the same codon can code for several amino-acids and the coding depends on context. I have considered this phenomenon from the TGD point of view in [L7]. Resonance could explain this phenomenon.

Dark mRNA codon could be in frequency resonance with dark tRNAs coding for different amino acids. The fraction of particular synonymous amino-acid produced in translation would naturally depend on how well the energy resonance condition is satisfied. Homonymy could also reduce to the level of tRNA: this happens if the coupling of the tRNA analog of RNA codon has energy resonance with several amino-acids.

3 How to produce beautiful bio-music?

Music expresses and produces emotions and harmonies in music correspond to emotions. Chemical representation of the genetic code should be the same irrespective of the emotional state of the gene represented at the magnetic body in terms of dark proton triplets also representing genetic codons and by music of light represents 3-chords of light with frequency ratios determined by one of the bio-harmonies.

This is achieved naturally. The correspondence between the chords of harmony and DNA and amino-acids does not depend on what vertex of icosahedron the base note (C for definiteness in the sequel) corresponds to. It also depends only on the shape of the Hamiltonian cycle invariant under isometries of the icosahedron. Furthermore, transponations of the scale by power of 3/2 plus projection to the basic octave do not affect the Hamiltonian cycle and therefore leave the correspondence with DNA codons and amino acids invariant.

The sequences of 3-chords would correspond to sequences of DNA codons mapped to sequences of amino-acids. Genes would be like music pieces. These music pieces would also serve as kind of names of passwords in 3N-fold resonance in communications between dark variants of basic biomolecules and between them and ordinary basic biomolecules. They would be like theme songs of TV series catching the attention or names essential for symbolic dynamics at the level of the basic biomolecules. The basic biomolecules in the same emotional state - that is having the same bio-harmony - could resonate and therefore couple.

What the rules for a beautiful bio-music could be? Could these rules select particular bio-harmonies and/or particular DNA sequences as allowed chord progressions and allow a deeper understanding of why particular genes are selected? Note that the condition that the chords of bio-harmony define 3N-resonances assignable to transitions of the basic biomolecules could lead to the selection of both harmony and biomolecules. A weaker condition is that ordinary biomolecules couple only to the sum of frequencies appearing in 3N-frequency assignable to dark codon.

3.1 Are beautiful chord sequences continuous in some sense?

The original model discussed in [L1, L8] started from a very conservative idea for what harmonic change of chord could be. The two chords should have at least a single quint. This fails for the chords with no quints. The resulting music pieces were also boring which is not a surprise: for instance, the transitions between basic chords C, F, G of C major scale are not possible.

This suggests that one should not start from music but from geometry. Let us consider isohedral geometry for simplicity and the proposed picture for the bio-harmonies.

1. Continuity in some sense is a natural requirement. The natural definition of continuity is that the sequence of 3-chords of progression should define a sequence of neighbouring triangles at the icosahedron. But how should one define neighborhood?

2. Concerning the notion of nearest neighbor, there are 3 options to consider.

   Option I: The strong form of continuity is that neighboring triangles have at least one common edge. This allows 4 different chord pairs. This would mean 4 possible DNA codon pairs for a given Hamiltonian cycle. For bio-harmony the symmetry of icosahedral harmony determined by Z_n ($n = 6, 4, 2$) can change and one would have 4+4+4=12 codon pairs. This kind of correlation for codon sequences would have been observed.

   Option II: For a weaker option the neighboring triangles would have at least 1 common vertex. A given triangle would have 4+3+2+1 =10 neighbors ("1" corresponds to the triangle itself as a neighbor). This would give 10+10+10 =30 possible codon pairs.

   Tetrahedral harmony gives further pairs but since one triangle of tetrahedron should correspond to a fixed triangle of icosahedron, this can change the situation for only a single chord. It is known that the minimum of 32 two codons are needed to code amino acids. The optimum situation very probably not reached for all bio-harmonies (if any), would be that the amino acid associated with the next codon can be any aminoacid. It should be easy to demonstrate by studying a sample of genes or more general DNA codon sequences to find that this prediction is wrong.

   Option III: For the weakest option the nearest neighbors would correspond to triangles at the orbits of the nearest neighbors in the sense of **Option II** or perhaps even **Option I** under the symmetry group Z_n of a given cycle. For instance, the transitions which would not change the codon would be replaced with all codons coding for the same amino-acid. The notion of nearest neighbor would reduce to the level of amino-acids: only the transitions to codons coding for the same amino-acid would be possible.

For the generalization of **Option I** Z_6 cycle would give 4 orbits of which several must be identical so that there are no problems. Z_4 cycle would give 4 orbits with 4 codons so that one amino acid is missing. For the Z_2 option one obtains only 4 2-origi so that 6 amino-acids are missing.

For the generalization of **Option II** 10+10+10 nearest neighbours would be replaced with their orbits. For the Z_6 cycle there are nearest neighbor 10 orbits and since there are only 4 orbits, there are no problems. For the Z_4 cycle one there are 5 4-orbits so that the minimal degeneracy of a given orbit is 2.

For the Z_2 cycle there are 10 2-orbits, and this number is obtained unless some 2-orbit occurs more than once. The 10 nearest neighbor triangles must correspond to different amino-acids: whether this is possible for all bioharmonies, remains an open question. In any case, it is plausible **Option III** can produce all possible codon pairs although this need not be the case for all bioharmonies. Could preferred bioharmonies be selected by the condition that all codon pairs are possible?

3.2 What about melody?

Melody is also an important part of music. A rough rule of thumb is that a beautiful melody tends to contain notes of the chord accompanying it. Dissonance is of course what makes music really interesting. This can be understood as a resonant coupling of the notes of the melody with the notes appearing in the accompanying chords.

Can one apply this picture to the music of light? Could the dark 3-photon states bound to a single unit by Galois confinement tend to decay to ordinary 3-photon states (bio-photons) and could melody represented as a sequence of single photon states couples resonantly to these photons? Could melody correspond to as sequence dark photons 1-plets decaying to ordinary bio-photons coupling to the the decay products of dark photon triplets representing genetic codons?

3.3 Summary

The basic results of the article are a precise definition of bio-harmony allowing to obtain the analogs of ordinary simple harmonies as special cases and a proposal that the 3-chord sequence defines a beautiful music piece if it corresponds to a continuous sequence for icosahedral faces. In principle this criterion allows bio-harmonies for which all possible codon pairings appear in chord sequences but some bio-harmonies might be excluded.

REFERENCES

Biology

[I1] Hofhuis J et al. The functional readthrough extension of malate dehydrogenase reveals a modification of the genetic code. *Open Biology*, 6(11), 2016. Available at: `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5133446/`.

Articles about TGD

[L1] Pitkänen M. Geometric theory of harmony. Available at: `http://tgdtheory.fi/public_html/articles/harmonytheory.pdf`., 2014.

[L2] Pitkänen M. Music, Biology and Natural Geometry (Part I). *DNA Decipher Journal*, 4(2), 2014. See also `http://tgtheory.fi/public_html/articles/harmonytheory.pdf`.

[L3] Pitkänen M. Music, Biology and Natural Geometry (Part II). *DNA Decipher Journal*, 4(2), 2014. See also `http://tgtheory.fi/public_html/articles/harmonytheory.pdf`.

[L4] Pitkänen M. E_8 symmetry, harmony, and genetic code . Available at: `http://tgdtheory.fi/public_html/articles/e8harmony.pdf`., 2016.

[L5] Pitkänen M. Can one imagine a modification of bio-harmony? Available at: `http://tgdtheory.fi/public_html/articles/toricharmony.pdf`., 2018.

[L6] Pitkänen M. Could also RNA and protein methylation of RNA be involved with the expression of molecular emotions? Available at: `http://tgdtheory.fi/public_html/articles/synapticmoods.pdf`., 2018.

[L7] Pitkänen M. Homonymy of the genetic code from TGD point of view. Available at: `http://tgdtheory.fi/public_html/articles/homonymy.pdf`., 2018.

[L8] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: `http://tgdtheory.fi/public_html/articles/gcharm.pdf`., 2019.

[L9] Pitkänen M. An Overall View about Models of Genetic Code & Bio-harmony. *DNA Decipher Journal*, 9(2), 2019. See also `http://tgtheory.fi/public_html/articles/gcharm.pdf`.

[L10] Pitkänen M. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group. Available at: `http://tgdtheory.fi/public_html/articles/SSFRGalois.pdf`., 2020.