Does valence bond theory relate to the hierarchy of Planck constants?

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Abstract

The findings about mysterious disappearance of valence electrons in rare earth metals due to heating leads to a new formulation of valence bond theory. The lengths of molecular bonds vary in rather narrow range whereas Schrödinger equation suggests that the bond lengths r should scale as $r \propto m^2/Z^2$ for $n = 1$ (m labels the rows of the periodic table). Closed shell electrons screen Z to $Z_{eff} = n_V$, n_V the number of valence electrons so that the formula $e = n^2m^2/Z^2_{eff}$ is a more natural starting point, and conforms with the basic idea about periodic system. This leads to a model allowing to estimate the value of n for given bond allowing also qualitative picture about electro-negativities of valence bonds. Also a comparison with bio-chemistry becomes possible. Hydrogen bond can be understood in terms of de-localization of proton. The conclusion is that the reductionistic dogma stating that molecular physics and chemistry reduce to atomic physics is wrong in TGD framework.

Contents

1 Introduction

The idea that valence bonds, or at least some of them, correspond to non-standard value of $h_{eff}/h = n$ [L5] is very attractive. It could allow to understand what chemical bonds really are and allow a detailed view about how reductionism fails in the sequence of transitions from atomic physics to molecular physics to chemistry to biochemistry.

1. The standard value of n, call it n_{min} need not correspond to $n_{min} = 1$ and the findings of Randell Mills [D1] [L3] suggesting that hydrogen atom and possibly also other atoms can have binding energies coming as k^2 multiples of ordinary ones with $k = 2, 3, 6$, suggests that $n_{min} = 6$ could correspond to the standard value of h_{eff} for atoms. $n > n_{min}$ would mean reduced binding energy and this would mean the possibility of high energy valence bonds.

2. The binding energy of atom would scale as $1/n^2$ so that for non-standard values of $n > n_{min}$ would correspond to smaller binding energy scale. The finding that heating of rare-earth atoms leads to a disappearance of some valence electrons [L6] suggests that the value of n for some valence electrons increases from n_{min} in these situation. The same effect might be achieved by irradiation at suitable photon energies corresponding to energy difference between ordinary state and dark state of electrons. An entire spectroscopy of atoms with dark valence electrons would be waiting to be discovered.

3. $n > n_{min}$ would explain why valence bonds are carriers of metabolic energy liberated in catabolic part of metabolism. The temporary reduction of of n would induce a temporary localication by shortening of flux tubes and in turn make possible bio-catalysis by kicking the reactants over the potential wall making the reaction slow. The shortening of long flux tube bonds between reacts as the value of n is reduced could explain why bio-molecules are able to find each other in the molecular crowd.

4. The Bohr radii of valence electrons of atoms scale as $a_B \propto m^2/Z_{eff}^2$, where m (usually denoted by n) is the principal quantum number determining the value of energy in the model based on Schrödinger equation. Z_{eff} is in good approximation equal to the unscreened nuclear charge $Z_{eff} = n_V$ equal to the number of valence electrons. If the superposition of atomic orbitals restricted to valence bonds is the essence in the formation of molecules, one an argue that the lengths of bonds and radii of molecules should decrease rapidly with Z_{eff}. However, the empirical fact is that the bond lengths vary in a rather narrow range, roughly by factor 2!

The solution of the problem looks rather unique.

1. The value of n assignable to the valence bond is scaled so that nm/Z_{eff} is near to unity so that the Bohr radius is near to that for hydrogen atom. Z_{eff} is naturally the charge unscreened by the closed electron shells and equal to the number $Z_{eff} = n_V$ of valence electrons. This conforms with the periodicity of the periodic table. Since the value of n is same for both bonded atoms, the value of Bohr radii differ which implies that electronic charge is shifted towards the atom with larger n_V and electro-negativities of atoms parameterizing this behavior are different for the atoms of the bond. This conforms qualitatively with the valence bond theory.

   For $n > n_{min}$ one would have $a_B \propto (n^2/n_{min})^2 m^2/Z_{eff}^2$, and if $nm/(n_{min}Z_{eff})$ is constant in reasonable approximation, the estimate for bond length does not depend much on Z. Could the weak variation of bond lengths be a direct indication that the reduction of molecular physics to atomic physics fails? Also the size of atoms in lattice about $2a_B(H)$ (one Angström) depends only weakly on Z_{eff}: could the constancy of $nm/(n_{min}Z_{eff})$ be true in reasonable approximation also for lattice bonds?

2. The predicted lengths of valence bonds should be realistic: this forces $n > n_H$ and $n \propto Z_{eff}$ is a rough guess. One should also understand the values of electro-negativities $\chi(X)$ allowing quantitative understanding about the distribution of charge along the bond. The bond lengths assignable to the bonded atoms are in general different and the one one with shorter bond length for electrons is expected to be more electronegative since the electrons for it are less de-localized.

2 Transition from atomic physics to molecular physics and chemistry

The transitions from atomic physics to chemistry and from chemistry to organic and bio-chemistries are poorly understood and the reductionistic dogma remain a mere belief. Could the valence bonds associated with magnetic flux tubes in TGD Universe and correspond to a non-standard value of n scaling up the value of Bohr radius by n^2? Could valence electron pairs form analogs of Cooper pairs with the length of bond defining the size scale of the Cooper pair. This could happen in aromatic cycles playing crucial role in molecular biology. Could various high energy valence bonds

making possible the storage of metabolic energy correspond to valence bonds with $n > n_{min}$ possessing therefore smaller binding energy.

One has several options.

1. U-shaped flux tube along single space-time sheet. U-shape would minimize magnetic energy.

2. One could have closed flux tube going along first space-time sheet A, going to second sheet B through extremely short wormhole contact of size of order CP_2 radius, and returning back along B and back to A through wormhole contact. One would have a pair of flux tubes with opposite values of magnetic fields on top of each other in CP_2 direction. The net magnetic field experienced by a charged particle at QFT limit would vanish: I have called this structure wormhole magnetic field. For wormhole magnetic field the average magnetic field determining the magnetic field at QFT-GRT limit of TGD would vanish in good approximation.

3. One could have single flux tube at sheet A going to B through wormhole contact and returning back along different route along B and returning back through wormhole contact. For a network of flux tubes one could have closed magnetic paths. In this case, charged particles would experience the magnetic field of only single flux tube. This option looks very attractive and one could realize Cooper pairs having members at different space-time sheets. The flux could be also monopole flux possible in TGD Universe thanks to the homology of CP_2.

First and third option look natural in the chemistry of valence bond. The prediction would be that valence electrons are de-localized along these bonds. If the wave function behaves like hydrogen atom wave function it decays exponentially with distance from each atom and a superposition of orbitals would be in question. The Bohr radius would be proportional to n^2 implying longer de-localization scale.

For hydrogen bonds proton would be de-localized as dark proton. This could represent transition from inorganic chemistry to organic chemistry. In TGD inspired quantum biology also other ions can be de-localized at magnetic flux tubes and these de-localizations represent a further steps away from atomic physics.

In biology n would serve as a kind of IQ for a system: understanding why this should be the case requires adelic physics serving as fusion of ordinary physics and physics of cognition represented by p-adic physics [K2] [L7]. The larger the value of n, the larger the maximal value of p-adic counterpart of entanglement negentropy, which is an analog of Shannon entropy but with algebraic number valued probability P appearing in $log(P)$ replaced by its p-adic norm $|P|_p$ for a suitable algebraic extension of rationals. This entropy can be negative and has in this case interpretation as information. The sum of real and p-adic entropies tends to be negative and has interpretation as a measure for conscious information.

2.1 Valence bond theory very briefly

How to test this hypothesis about valence bonds? Electronegativity and oxidation/reduction serve as the basic notions in valence bond theory (see `http://tinyurl.com/y8wyd9zm`). Valence rule tells which bonds are favored. Bond lengths and electro-negativities are basic parameters characterizing bonds. Can one interpret these notions in terms of $n = h_{eff}/h$ hierarchy of dark matters?

1. For atom, call it A, bonded to atoms B, C,.. the sum of valences of B, C,.. is the negative of the valence of A. For H-Cl and Na-Cl the valences are +1 and -1. C as valence 4 (or equivalently -4) and CH_4 represents example of this compensation. For O_2= O=O one as double valence bond.

2. Bond length is the first key parameter allowing to get idea about valence bond. The table of Wikipedia article about the notion of bond length gives the bond lengths of C with other elements (see `http://tinyurl.com/ya4md73c`). Interestingly, C-H, C-C, C-O, C-N, C-S, C-Se bond lengths vary, which might have interpretation in terms of varying value of n: all bonds are important in biology. An alternative explanation for the variation would be that there are also other atoms involved.

   The range of variation is [106, 112] pm for C-H; [120, 154] pm for C-C (the upper limit is achieved for diamond but even longer bond lengths are known), [147, 270] pm for C-N , [143,

215] pm for C-O (note that bond length for C-O-H is thus longer than for C-H), and [181, 255] pm for C-S.

Average bond lengths tend to decrease along the row of the periodic table and increase along column. The C-X bonds in hydrocarbons (alkenes, alkynes) are shorter than in organic polymers in general, which supports the view that they have as organic but non-living materia lower value of n than organic compounds in living matter. The bond lengths for C-metal bonds are rather long, for instance for C-Mg bond length is 207 pm, roughly twice C-H bond length.

3. Electronegativity χ is second key parameter and allows a quantitative description of valence bonds. The rule is that the electrons of an atom with smaller electronegativity χ , call it A, tend to be nearer to those of the atom B with higher value of χ: one says that B oxidizes A and B is reduced. Both oxidation and reduction occur always and one talks about redox reactions, which are fundamental in biology. The term oxidation follows from the fact that oxygen O_2 is the best known oxidant.

   The values of electronegativity for various elements are listed in Wikipedia article (see `http://tinyurl.com/pbh6r6c`) and give a rough idea about what happens for the valence electrons in various bonds. The reduction to two-atom level is only an approximation since the presence of other atoms modifies χ. For instance, the electro-negativities of C for C=O and C-(O-H) are different.

   For instance, one has $\chi(X) \in \{2.20, .98, .93, 1.00\}$ for $X \in \{H, Li, Na, Ca\}$ with $(m, Z) \in \{(1, 1), (2, 7), (3, 11), (4, 20)\}$. Clearly, one has $\chi(H) \sim 2\chi(X)$.

   A naive expectation is that the atom with the smaller value of n/Z is more electronegative (note that valence rule must be satisfied). Indeed, electronegativity increases along the row of the periodic table. Electronegativity decreases slowly along the column of periodic table except for the metals in the columns containing Cr, Mn, Fe, Co, Ni, Cu, Zn at top row. Understanding the explicit dependence between $\chi(X)$ and $a_B(x)$ and other parameters involved would require a more detailed model.

2.2 Deducing an estimate for the value of $n = h_{eff}/h$ from bond lengths

Valence bond lengths provide information allowing to estimate the value of $n = h_{eff}/h$.

1. The expectation is that the bond length for bond A-B scales as the minimum of Bohr radius for the two atoms that is minimum value of $a_B \propto n^2m^2/Z^2$ for atoms A and B. Here one has $n = h_{eff}/h$, m (usually n) denotes the principal quantum number of valence electron, and Z the charge of the atomic nucleus. The atom with smaller value of m/Z should dictate the bond length.

2. If bond length assumed to be of order Bohr radius as function of (Z_{eff}, m), its reduction as function of m/Z_{eff} is quite too slow to be consistent with m^2/Z^2_{eff} behavior expected for ordinary Planck constant (see the table of `http://tinyurl.com/pbh6r6c`). The formula $a_B \propto n^2m^2/Z^2_{eff^2}$ and the increase of n as function of Z_{eff} compensating the reduction of a_B due to the increase of Z_{eff} for valence bonds is suggestive.

   The first guess is that the formula $a_B(nZ_{eff}/m) = a_H$ holds true apart from factor of order 2. This would explain why valence bond lengths vary in so narrow length scale range. This fact could be even seen as argument against the reduction of chemistry to atomic physics.

The model is based on the following arguments.

1. The value of n is same for both atoms at the ends of the bond. Since the Bohr radius of atom with smaller value of nm/Z_{eff} gives rise to a smaller de-localization length of orbitals, the value of n for heavier atom, call it X, determines the length of flux tube which should be of order $2 \times a(X)$. Since the Bohr radius of the atoms with larger value of nm/Z_{eff} is longer, the electrons of this atom are more de-localized and tend to be nearer to atom with the smaller value of nm/Z_{eff}. The higher the value of Z with same value of m for both atoms the higher the electronegativity. This conforms with empirical facts.

2. The electronegativity of H is roughly twice the electronegativity of the alkali-atoms in the above example. The naive application of the above argument this would suggest that nm/Z_{eff} for alkali atoms must be larger than n so that de-localization of electron of alkali atom would make hydrogen atom more electronegative. This of course cannot be the case. The solution of the problem is that one cannot apply the rule without taking into account valence rule. For C, N, O, F and S, Cl the electro-negativities are higher than for H. Note that one has $\chi(P) = 2.19 \sim \chi(H) = 2.20$. Interestingly, P occurs with valence 5 in phosphate.

3. $n(H) = 6$ suggested by the findings of Mills [D1] [L3] and will be assumed.

With these assumptions, one can consider two options fixing the value of $n(X)$ using as a guideline empirical data about bond lengths telling that they vary in rather narrow rang $[2, 6]a_H$.

1. For Option I one would have $a(X) = a_B(H)$ implying that all Bohr radii and bond lengths are same and equal to those for hydrogen. Bond length would be in good approximation twice the hydrogen atom Bohr radius: $r = 2a_H$. This condition is satisfied approximately for quite a number of bond lengths. The radii however vary roughly in the range $[1, 3] \times 2a_H$.

   Option I would give

$$n^2(X) = (\frac{Z_{eff}}{m})^2 n^2(H) \quad .$$

   For given row characterized by the value of m one would have

$$n(Z, m) = \frac{Z_{eff} n_H}{m} = \frac{6Z_{eff}}{m} \quad .$$

2. $n_H = 6$ proportionality for n allows besides $n = Z_{eff} n_H/m$ also more general option: call it Option II. One can have

$$n(X, \frac{k}{l}) = \frac{l}{k} \times n(Z_{eff}, m) = \frac{l}{k} \times \frac{6Z_{eff}}{m} \quad ,$$

   where $k \in \{2, 3, 6\}$ is non-trivial divisor of $n_H = 6$ besides. This scales the Bohr radius $a(mn/Z_{eff}) = a_H$ to

$$a(mn/Z_{eff}) = (l/k)^2 a_H \quad .$$

   For instance, $l/k = 3/2$ would give Bohr radius $a(X) = 9a_H/4$ somewhat above $2a_H$. $l/k = 4/3$ would give Bohr radius $16a_H/9$ and $l/k = 5/3$ would give Bohr radius $a(X) = 25a_H/9$ slightly below $2a_H$. The largest bond lengths are about $6a_H$. These two mechanisms could explain the variation of the bond length. This option would explain the bond lengths which $1 - 3$ times the minimal bond length $r = 2a_H$.

3. The value of the Bohr radius is not affected much if $n(Z_{eff}, m)$ is replaced with the nearest integer. This because for large enough n one the relative change $\Delta r/r = \Delta a_B/a_B$ satisfies $\Delta r/r \simeq 2\Delta n/n = (2m/Z_{eff} n_H)\Delta n = (m/3Z_{eff})\Delta n$. This allows fine tuning of the bond length for both options.

Consider now different rows of the periodic table for Option I. The lengths for Option II can be deduced from this option by scaling by $(k/l)^2$, $l = 2, 3, 6$.

1. $m = 2$: For $X \in \{Li, Be, B, C, N, O, F\}$ with $Z_{eff} \in \{1, ..., 7\}$ and $m = 2$ one $n(Z_{eff}, m) = 3Z_{eff} \in \{3, 6, ..., 18, 21, \}$. The highest values of n are in this row and this might be of biological significance. Indeed, large n means large metabolic energy and C,N, and O are fundamental in metabolism.

2. $m = 3$: For $X \in \{Na, Mg, Al, Si, P, S, Cl\}$ one has $m = 3$, $Z_{eff} \in \{1, .., 7\}$. One $n(Z_{eff}, m) = 2Z_{eff}$ $n(X) \in \{2, 4, ..., 14\}$. The common values of n are in $n = 6$ corresponding to Be and Al and to $n = 12$ corresponding to C and S: note that also S corresponds to large metabolic energy. Note that P and S with $n = 12, 14$ are also important in metabolism. Whereas the lighter atoms serve control purposes.

3. $m = 4$: $X \in \{K, Ca, Sc\}$ have $Z_{eff} \in \{1, 2, 3\}$, metals $\{Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn\}$ have $Z_{eff} \in \{4, ..., 12\}$ and $\{Ga, Ge, As, Se, Br\}$ have $Z_{eff} \in \{13, ..., 17\}$ have $m = 4$. One has $n(Z_{eff}, m) = 3Z_{eff}/2$ having also half odd-integer values. This gives $\{1, 3/2, 2\}$ for $X \in \{K, Ca, Sc\}$ and $\{5/2, ..., 17/2\}$ for $\{Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn\}$ and $\{9, ..., 11\}$ for $\{Ga, Ge, As, Se, Br\}$. The total variation range for n is $[1/2, 11]$.

   Alkali atoms K, Ca and metals Mn, Fe, Co, Ni, Cu, Zn are biologically important. The corresponding metabolic energies are however not so large as for lower rows and this ions indeed seem to serve for control purposes. (Li,Be,B) and (V,Cu,Ga) have same values of n as also (Na,Mg,Al,Si,P) and (Sc,Mn,Co,Cu,As). Interestingly As is reported to play the role of P in some exotic metabolism.

   One could understand the deviations of bond length from the ideal value by allowing small variations of $n(Z_{eff}, m)$. In particular, the replacement of half-odd integer with integer would not considerably affect the bond length.

4. $m = 5$: For $m = 5$ the values of $n(Z_{eff}, m)$ are not integers for the proposed model unless Z_{eff} is divisible by 5. One has $Z_{eff} \in \{1, ..18\}$. The maximum integer value of n is 3. This allows only Nb, Pd,Sb. Could this relate to the fact that heavier atoms are not so important biologically? The atoms near these 3 atoms

5. $m = 6$: For $n_H = 6$ one has $n(Z_{eff}, m) = Z$ for $m = 6$ atoms. Could integer valuedness mean that these atoms might be somehow special?

6. The scale of variation of n degreases with m and this suggests smaller scale of variation for both valence bond length and electron-negativity. The range for the variation of latter indeed decreases along the columns of the periodic table. Also the values of n decrease along the colum of the periodic table: also this conforms with the empirical facts.

To sum up, it seems that one can understand bond lengths quite satisfactory and deduce from the the values of n if the proposed model is accepted. The most important outcome would be explanation for the fact that bond lengths do not scale like $(m/Z_{eff})^2$ as standard quantum theory would suggest.

2.3 About biological interpretation

$h_{eff}/n = n$ for valence bond serves as a kind of IQ and also for the metabolic energy carried by molecule in valence bonds. This suggests that biologically important molecules should have larger value n. One can test this hypothesis.

1. Difference in χ means that valence electrons are shifted toward the more electro-negative atom of the valence bond. As found, the larger value of $a_B(nm/Z_{eff}))$ for the atom with smaller value of nm/Z_{eff} allows to understand why it is more electronegative.

2. By the above proposal large value of mn/Z_{eff} corresponds to long valence bond and therefore de-localization of valence electron to long scales. The length of valence bond presumably depends also on other parameters. In any case, bond length could be taken as a rough indication about the value of n associated with the bond and the above estimate for n can serve as a starting point. The variation of bond length might allow interpretation in terms of variation of n.

3. The shortest bond lengths would correspond to smallest value of n possibly assignable to what is identified as waste in metabolic reactions. Small value of n also means large binding energy so that the waste molecules in cellular respiration should have short valence bonds. High energy phosphate bond (...P-O-P...) between two phosphates - say in ADP and ATP -

would correspond to a large value of n and the bond should be long. Note that P behaves as valence 5 element in phosphate.

Consider the possible implications in more detail.

1. C and Si atoms are expected to form linear polymer-like structures with long valence bonds and large and varying value of n proportional to $Z_{eff} \simeq n_V$, n_V the number of valence electrons and guaranteeing that the bond length has correct value varying in rather narrow range. Of course, bonding of atoms with additional atoms as occurs in multi-phosphates could allow also linear structures. This could partially explain why life is Carbon based.

   The proposed valence theory allows a view about the role of C. The length of C-H bond is determined by $n(C)$ with larger $n_V(=4)$ so that the valence electron tends to be nearer to C: $\chi(C) = 2.55 \geq \chi(H) = 2.2$ conforms with this. $n(C-H) = n(C-C)$ predicted. The high negentropy of C-H bond could explain why also C-H bonds are so typical in biology. Note that petroleum consists of carbohydrates and liberates energy, supporting the view that non-standard value of n is associated with the valence bonds also in this case.

   Graphite is obtained by putting 2-D graphene layers on each other. In graphite C has valence bonds to 4 C:s and in graphene to 3 C:s. An interesting question is whether this might relate to some very special properties of graphene and whether it might correspond to larger than usual value of n. Not that these structures, in particular graphite, are much less dynamical than polymers.

2. Si is second candidate for the basic atom of life. The values of n for C-H bonds and C-C bonds are in good approximation proportional to n_V/m and in ratio $n(m=2, Z_{eff})/n(m=3, Z_{eff}) \simeq 3/2$. $n(C) > n(Si)$ implies that C-H and C-C bonds are more negentropic and energetic favoring Carbon based life. Also the C-N and C-O bonds are more negentropic and energetic than Si-P and Si-S bonds.

   Note also that $\chi(Si) = 1.9$ is smaller $\chi(H) = 2.20$ so that the electron is nearer to H making it effectively negatively charged. Silanes (hydrosilicons) are very reactive. Also this could relate to the fact that Si based life is not realized.

2.3.1 Redox reaction and energy metabolism

Oxidation means the transfer of electrons towards more electronegative atom - not necessary oxygen - and means shorter de-localization scale for electrons and shorter bond unless the value of n increases.

1. Oxidation happens when nutrients are catabolized so that they give the metabolic energy stored into the valence bonds, which could be rather stable due to the non-standard value of n. This rule would hold true quite generally. Bio-catalysis would temporarily reduce the value of n for various bonds and liberate energy allowing to kick the reacting molecules over the potential wall preventing the reaction.

2. Aerobic cell respiration relies on oxygen. At the bottom of the catabolic cascade is glucose C_6H_{12} O_6 decomposed into CO_2 =O=C=O and water. The liberated energy is used to transform ADP to ATP. C=O group acts as the functional group because C is effectively slightly positively charged and attracts negative ions and negative parts of molecules so that it is highly reactive. C=O bond length is 116 pm and considerably shorter than C-O bond length (in say C-O-H) (about 143 pm in paraffin, see `http://tinyurl.com/y95bkooa`). This conforms with the assumption that n is smallest in CO_2 so that in this sense it would be waste.

   Note however that the value of n is higher than $n = n_H = 6$ (taking seriously the findings of Mills [D1] [L3] also for O in CO_2. This should relate to the special role of CO_2 and $H_2(O)$ concerning life. In fact, in both cases the value of $n(O)$ for bonds involved is almost maximal possible in the entire periodic table. Only F has larger n but is too reactive. Hence O is optimal choice both negentropically and energetically. S is second candidate for the role of O but $n(S)$ is by factor 2/3 smaller. Hence $m = 2$ row of the periodic table is optimal for life.

Remark: A rough estimate of the proposed valence bond theory for the ratio of the values of n for C-C and C-O bonds assuming that all bonds have the same length would be $n_V(O)/n_V(C) = 3/2$.

3. The waste products of metabolism should consist of compounds, which do not have C-C bonds, in particular molecules having only single C atom. The flux tubes associated with the valence bonds should have low value of n and correspond to low molecular IQ. Bond lengths and de-localization lengths should be short. The molecules should involve typically single carbon atom or no carbon atoms.

   Carbon di-oxide CO_2 with valence structure O=C=O represents basic example about outcome of oxidation. CO_2 is the basic organic waste product of metabolism and indeed has especially short bond length. C=O group is functional since oxidation makes C slightly positively charged so that it attracts negative ions and negatively charged parts of molecules. Also ammonium NH_3 is waste product and now electrons are shifted towards N as one finds by comparing the electronegative of H and N appearing in the table of Wikipedia article (see `http://tinyurl.com/pbh6r6c`). As already noticed the notion of "waste" is only relative notion.

   Urea (H_2-N)-C(=O)-(N-H_2) is second waste product. As a matter of fact, liver forms urea and water by combing CO_2 with two NH_3 (ammonium) molecules. Liver puts two waste molecules to single packet.

4. Also H_2O has high negentropy and energy contents although it appears as "waste" in cell respiration. The presence of hydrogen bonds between water molecules gives rise to dark protons, which also affects the situation. Photosynthesis indeed has water and CO_2 input elements so that it makes sense for them to have high negentropy and energy content.

   Remark: Solar light would generate negatively charged exclusion zones of Pollack [L1] [L1] crucial for life.

One can look the situation also from the view point of storage of metabolic energy and negentropy.

1. Hydroxy group O-H (see `http://tinyurl.com/y7uv924k`) attached to C appears in sugars with chemical formula $C_nH_{2n}O_n$. For the simplest hydrocarbons one would have formula C_nH_{2n} apart from boundary corrections at the ends of the polymer. Sugars store more metabolic energy than hydrocarbons and the valence theory should allow to understand this. The rough estimate of the proposed valence bond theory for the ratio of the values of n for C-O and C-H assuming that all bonds have the same length would be $n_V(O)/n_V(C) = 3/2$. This predicts that sugars are more negentropic and energetic than hydrocarbons.

2. C-O bond length is in the range [143,215] pm and C-H bond in the range [106,112] pm. The value of n for C-O-H bond must be higher than predicted by the assumption that the bonds have equal lengths. The replacement $n(O) \to 3/2n(O)$ allowed by $n_H = 6$ would predict that the ratio of C-H and C-O bond lengths is 9/4. Smaller variations of $n(O)$ are also possible. This would increase further the negentropy and energy contents of O and conform with Negentropy Maximization Principle (NMP), whose statistical form is a prediction of adelic TGD [L7] [K2].

3. The Wikipedia article about hydroxy group tells that compounds containing hydroxyl groups (O-H) tend to form hydrogen bonds forcing them to stick together. This would mean formation of dark protons and suggests formation of flux tube networks, which could be also behind the formation of water molecule clusters and be fundamental aspect in the formation of systems with life-like properties [L5] (see `http://tinyurl.com/yassnhzb`). O-H is thus favored over H also for this reason.

4. One can understand also the somewhat mysterious high energy phosphate bond. Phosphate has chemical formula $(P{=}O)O_3^-$. In phosphate the contents of metabolic energy and negentropy are maximized for the proposed model for valence bonds since only F has higher value of n than O in the periodic table assuming that bond lengths are identical. The actual bond lengths require that the value of $n(O)$ is even higher than this.

2.3.2 DNA, RNA, and amino-acids

What about other biomolecules such as DNA and amino-acids?

1. DNA (see `http://tinyurl.com/cpndtse`) involves the backbone consisting of a sequence of phosphates $(P{=}O)O_3^-$ and ribose molecules. The 6-cycles of ribose molecules contain 5 carbon atoms and one oxygen atom. As already noticed, phosphate has very high energy and negentropy contents. P has very nearly the same electronegativity (2.19) as H (2.20) and O has electronegativity 3.44 so that the P-O bonds resemble H-O bonds as far electronegativity is considered.

   The aromatic 5- and 6-cycles of DNA involving de-localized electrons contain two N atoms besides C atoms. The electro-negativities are $\xi(C) = 2.55$ and and $\xi(N) = 3.04$ so that electrons should be nearer to N. The length of C-N bond is longer than C-C bond so that the values of n could be the same and n for C-N bond could be even higher than for C-C bond so that it would be more negentropic. This could explain why nitrogens are present in DNA rings rather than only carbon atoms. Note that DNA strands are connected by $N\cdots N$ and $N\cdots O$ hydrogen bonds possibly involving dark protons.

   In RNA (see `http://tinyurl.com/cmvyw2r`) one C-H in the ribose is replaced with C-O-H in pentose ring. A, T, C, G are replaced with A, U, C, G (T is methylated form of U obtained by replacing -H with $-CH_3$). Only short strands of RNA appear and RNA does not have double stranded form but has single stranded form forming double helix. An interesting question is why the replacement of C-H with C-O-H in the pentose inducing change in electronic charge distribution affects so dramatically the properties of DNA. O-H group is functional and involved with the formation of hydrogen bonds. Maybe quantum criticality of ribose has something to do with the widely different properties of DNA and RNA.

2. Amino-acids (see `http://tinyurl.com/jsphvgt`) have structural formula H_2N- ((C-H)-R)-((C=O)H)-OH, where R is the residue responsible for the functional properties of the amino-acid. Amino-acid polymers have backbone involving N-C bonds formed between amino-group N-H_2 and carboxyl group (C(=O)H)-OH by hydrolysis giving rise to peptide bond ...(C(=O)H)-NH... plus H_2O. Therefore the backbone consists of ...-(C(=O)H))-(NH)-...-(C(=O)H))-(NH)... sequence containing ((C-H)-R) between molecules of the backbone.

   Assuming same N-C and C-C bond lengths the proposed valence band theory predicts $n(N) = (n_V(N)/n_V(C)) = 5n(C)/4$ implying that higher content of metabolic energy and negentropy favors C-N bonds instead of C-C bonds. That the catabolism of peptides to sugars liberates metabolic energy conforms with this.

2.4 About the biological role of low valence ions

A comment about the role of biologically important ions is in order. As a rule they tend to have low valence, especially those whose cyclotron frequencies for $B_{end} = .2$ Gauss seem to be important biologically. The possibly existing valence bonds between atoms towards the left end of the rows of the periodic table (Li,Na,K,Ca, Mg,..) - if they even exist at all - have low valence and low value n satisfying $n \geq 6$ (note that the valence of the bond is the valence of the atom with higher valence).

1. The potential negentropy content of low valence bonds is low and also metabolic energy content defined as difference of energy from the situation in which one has $n = 6$ derived from the experiments of Randell Mills [L3]. Thus low valence bonds are not important for metabolism.

2. Low valence ions have however different role: they appear as biologically important positive ions important for the communications to and control by MB. For instance, dark photons with cyclotron frequencies in magnetic fields of flux tubes would be involved with control by dark photons. These dark photons could also transfer energy to MB. The values of n for dark photons can be as high as $n \sim 10^{12}$ or even higher from the condition that the energies of dark photons with frequencies in EEG range are above thermal energy or even in visible and UV range for bio-photons.

Values of n for dark ions could be thus much higher than for electrons at valence bonds if their cyclotron energies correspond to dark photon energies. Dark photons and dark cyclotron condensates would represent a higher level of evolutionary hierarchy and control and coordination in quite long length scales responsible for the quantum coherence of living matter.

Remark: Recall that the assumption $\hbar_{eff} = \hbar_{gr} = GMm/v_0$, where $v_0 > c$ has dimensions of velocity, m mass of the charged particle, and M some large mass, guarantees universality of cyclotron energy spectrum (spectrum of bio-photons in visible and UV range). This gives $n \sim 10^{13}$ for 10 Hz cyclotron frequency photon energy about 1 eV. Fe^{++} has $f_c = 10$ Hz in $B_{end} = .2$ Gauss.

2.4.1 Some examples about biologically important ions

One can consider some examples about biologically important ions.

1. In TGD protons H^+ appear as dark protons. The small value of the atomic binding energy would explain why hydrogen appears as ion: dark atoms with this value of n would have extremely large size. Dark protons need not of course have the value of n characterizing dark EEG photons. Rather, entire hierarchy of frequency scales is expected ranging down to the energies of IR photons still above the thermal energy.

2. Hydrogen bond carrying de-localized proton would serve as the simplest example and be associated with magnetic flux tube. Hydrogen bonded water molecule clusters are crucial for life. Hydrogen bonds are also formed between OH groups of say water and some other high valence atoms.

   Dark DNA/RNA/amino-acid/tRNA realized as dark proton sequences at magnetic flux tubes and realizing vertebrate genetic code (prediction) would be second realization giving rise to dark nuclei [L2]. Cell membrane as generalized Josephson junction would involve electronic Cooper pairs and dark protons or even their Cooper pairs [K1]. At microscopic level membrane proteins defining various ion channels and pumps would act as generalized Josephson junctions.

3. What about heavier ions? Their dark variants appear at MB and play a key role in TGD based model for quantum biology and neuroscience. They appear at flux tubes assignable to generalized Josephson junctions and at layers of MB in much longer scales (note that hydrogen bond is analogous to Josephson junction). Dark ions carrying much more information in BE condensates than dark valence electrons would serve control purposes whereas dark electrons at valence bonds would carry metabolic energy.

4. What about noble gases? Can one say that they have maximal valence or do they have vanishing valence and therefore $n = 6$ as the findings of Mills suggest? If they had maximal valence they should be biologically important but they are not: thus $n = 6$ identification is feasible. Ions at the right end of the rows of periodic table, say Cl^- ion, are like noble gas atoms as far as valence is considered. The electronic negentropy of H-Cl understood as H^+ bonded with Cl^- (ionic bond rather than valence bond) and metabolic energy content would be minimal. Cl^- could however form cyclotron condensates with a large value of n, which would explain its biological importance.

   Amusingly, plastic balls in plasma of Ar^+ ions appear in the experiment demonstrating life like properties of this system ("breathing") [L5]. Ar^+ would have maximal possible valence and thus maximal value of n and would appear at flux tubes.

2.4.2 How the ionization is possible in living matter?

The appearance of ions in living matter looks mysterious. Same is true concerning ions in electrolytes. It is easy to talk about cold plasma but much more difficult to answer the question how this cold plasma can be created. Usually the formation of plasma involves ionization, which requires high temperature of order of the atomic binding energy for the

valence electrons of the atom. For hydrogen atom the binding energy is around 13 eV, which corresponds to a temperature of roughly 130,000 Kelvin! This is three orders of magnitude higher than room temperature! In electrolyte the presence of rather weak electric fields cannot explain why the ionization takes place.

For some reason chemists and biologists do not spend much time in pondering fundamentals and theoreticians enjoying monthly salary have a highly irreverent attitude to these disciplines as an intellectual entertainment of lower life-forms. Therefore also this question has been guided under the rug and stayed there.

TGD based explanation for the paradox is simple. If the value of $h_{eff</sub/sub>/h=n}$ for valence electrons is high enough, the binding energy, which is proportional to $1/n^2$, becomes so high that a photon with rather low energy, say infrared (IR) photon, can be ionize the dark atom. One can say that the atoms in this state are quantum critical, a small perturbation can ionize them.

(a) In the TGD based model of cold fusion as dark nucleosynthesis the atoms would have n=2^{12} = 2056$and the ionization would create dark nuclei as sequences of dark protons at magnetic flux tubes$ 1001[L4].

(b) In the TGD based model for the analogs of DNA/RNA/amino-acid sequences/tRNA as dark proton sequences the value of n would be of the order of 10^6 higher so that the distance between dark protons, would be a same as between DNA letters, about 3 Angstroms. For these values of n dark atoms are unstable at room temperatures.

(c) In Pollack effect [L1] the irradiation by IR light or visible light or by pumping energy to the system by some other means produces negatively charged exclusion zones (EZs) in which water molecules form hexagonal layers and obey the effective stoichiometry $H_{3/2}$ O. Part of protons (every fourth) goes to magnetic flux tubes as dark protons. How it is possible to create this state by IR radiation?

i. The original assumption was that in second OH bond of water molecule is excited to a high energy state near to ionization energy so that IR photon can split the bond. The question is: why and how? Do the UV photons from solar radiation cause the excitation?

ii. A more elegant option is that the value of n for the second O-H bond is so large that the bond binding energy is so small that IR photon can split the bond. Solar UV photons could induce the dark excitation. Taking 5 eV as rough estimate for the bond binding energy in the normal state water, this requires the reduction of energy by a factor of order $10^3 to give IR energy. 05eV (energy scale assignable to the membrane potential eV). n$ $32 from its value for O-H bond according to standard chemistry. A small push by absorption of IR photo$ H bond and created dark proton at flux tube. Any perturbation feeding to the system this energy can induce

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