Exploration

The Anomalies of Water as Evidence for the Existence of Dark Matter in TGD Framework

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Abstract

The physics of water involves numerous anomalies. The structural, dynamic and thermodynamic anomalies form a nested in density-temperature plane. For liquid water at atmospheric pressure of 1 bar the anomalies appear in the temperature interval 0-100 °C. Hydrogen bonding creating a cohesion between water molecules distinguishes water from other substances. Hydrogen bonds induce the clustering of water molecules in liquid water. Hydrogen bonding is also highly relevant for the phase diagram of H_2O coding for various thermodynamical properties of water. In biochemistry hydrogen bonding is involved with hydration. Bio-molecules - say amino-acids - are classified to hydrophobic, hydrophilic, and amphiphilic ones and this characterization determines to a high extent the behavior of the molecule in liquid water environment. Protein folding represents one example of this. Anomalies are often thought to reduce to hydrogen bonding. Whether this is the case, is not obvious to me and this is why I find water so fascinating substance. TGD indeed suggests that water decomposes into ordinary water and dark water consisting of phases with effective Planck constant $h_{eff} = n \times h$ residing at magnetic flux tubes. Hydrogen bonds would be associated with short and rigid flux tubes but for larger values of n the flux tubes would be longer by factor n and have string tension behaving as $1/n$ so that they would softer and could be loopy. The portional of water molecules connected by flux tubes carrying dark matter could be identified as dark water and the rest would be ordinary water. This model allows to understand various anomalies. The anomalies are largest at the physiological temperature 37 °C, which conforms with the vision about the role of dark matter and dark water in living matter since the fraction of dark water would be highest at this temperature. The anomalies discussed are density anomalies, anomalies of specific heat and compressibility, and Mpemba effect. I have discussed these anomalies already for decade ago. The recent view about dark matter allows however much more detailed modelling.

1 Introduction

The motivation for this brief comment came from a popular article telling that a new phase of water has been discovered in the temperature range 50-60 °C (see `http://tinyurl.com/h4wlf6o`. Also Gerald Pollack [5] (see `http://tinyurl.com/oyhstc2`) has introduced what he calls the fourth phase of water. For instance, in this phase water consists of hexagonal layers with effective $H_{1.5}O$ stoichiometry and the phase has high negative charge. This phase plays a key role in TGD based quantum biology. These two fourth phases of water could relate to each other if there exist a deeper mechanism explaining both these phases and various anomalies of water.

Martin Chaplin (see `http://www1.lsbu.ac.uk/water/`) has an extensive web page about various properties of water. The physics of water is full of anomalous features and therefore the page is a treasure trove for anyone ready to give up the reductionistic dogma. The site discusses the structure, thermodynamics, and chemistry of water. Even academically dangerous topics such as water memory and homeopathy are discussed.

One learns from this site that the physics of water involves numerous anomalies (see `http://tinyurl.com/hs77fsh`). The structural, dynamic and thermodynamic anomalies form a nested in density-temperature plane. For liquid water at atmospheric pressure of 1 bar the anomalies appear in the temperature interval 0-100 °C.

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Hydrogen bonding creating a cohesion between water molecules distinguishes water from other substances. Hydrogen bonds induce the clustering of water molecules in liquid water. Hydrogen bonding is also highly relevant for the phase diagram of H_2O coding for various thermodynamical properties of water (see http://tinyurl.com/hr77ou5). In biochemistry hydrogen bonding is involved with hydration. Biomolecules - say amino-acids - are classified to hydrophobic, hydrophilic, and amphiphilic ones and this characterization determines to a high extent the behavior of the molecule in liquid water environment. Protein folding represents one example of this.

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Some examples about anomalies are in order.

1. The high cohesion between water molecules due to hydrogen bonds gives it exceptionally high freezing and boiling points. The high latent heat of evaporation implied by hydrogen bond gives a high resistance to hydration and high evaporative cooling. Hydrogen bonds also give rise to an especially high surface tension.

   Water has unique hydration properties with respect to the basic biomolecules. Hydration leads to the formation of gels, which can reversibly undergo gel-sol phase transitions important for the physics of life. Water ionizes easily and proton transfer reactions between molecules giving rise to rich interactions in biochemistry.

2. Solid (liquid) water has anomalously low (high) density so that the difference between densities of liquid and solid states is small. In the range 0-4 °C water compresses (becomes more dense than solid phase) when heated at constant pressure rather than expanding as other liquids. This anomaly is fundamental for life.

3. Water has anomalously high specific heat capacity $c_p = dC_p/dM$, $C_p = (dE/dT)_p$. This might be understood in terms of breaking of hydrogen bonds giving rise to new translational degrees of freedom as water molecules begin to move freely.

   The specific heat capacity c_p of liquid water at atmospheric pressure decreases in the interval 5-37 °C, and increases in the range 37-100 °C. The minimum is at physiological temperature (see http://tinyurl.com/zfv22yz) - hardly an accident. For other liquids c_p increases steadily in this interval. The compressibility of water depicts similar behavior distinguishing water from other liquids.

4. Mpemba effect (see http://tinyurl.com/7h2h59p) means that hot water freezes faster than cold water. The effect is maximal at 35 °C, which is remarkably close to the physiological temperature. Mpemba effect challenges the naive views about what happens in freezing, and several explanations have been proposed.

2 The anomalies of water in TGD framework

What TGD can say about these anomalies? I have already earlier considered a model of water explaining some of the basic anomalies and it is interesting to see whether the recent understanding of TGD might allow more precise articulation of the basic ideas.

1. The TGD inspired model assumes that water consists of ordinary water plus dark water. Dark matter is identified in TGD framework as phases of ordinary matter but with effective Planck constant h_{eff}, which is integer multiple $h_{eff}/h = n$ of the ordinary Planck constant. This proposal is motivated by several experimental findings. In particular, Pollack effect leading to a generation of negatively charged exclusion zones (EZs) with effective stoichiometry of water to $H_{1.5}O$ would be due to the transfer of one-over-fourth of protons do dark protons at magnetic flux tubes.

One must be careful in defining what "dark" means. Does dark matter include only the dark particles at flux tubes or does it include also the water molecules connected by these flux tubes? The following considerations suggest that the latter definition allowing to talk about dark water is more appropriate.

2. The dark matter at magnetic flux tubes could involve also other particles than protons (electrons and even ions) and would serve as the "boss" controlling biochemistry in TGD based view about biology. The communications between visible matter and dark particles at magnetic flux tubes would rely on dark photons with energy $E = h_{eff}f$, which can be above thermal energy for even EEG frequencies. This makes possible interaction between widely different length and time scales.

3. $h_{eff}/h = n$ phases would be generated at quantum criticality and serve as correlates for long range correlations and fluctuations at criticality. The transformation of ordinary protons to dark protons and vice versa could be essential for proton transfer reactions and even give rise to high Tc superconductivity along dark flux tubes based on pairs of parallel flux tubes carrying the members of Cooper pairs.

4. Several values of h_{eff}/h are possible. The matter visible to us need not correspond to the minimal value of h. The hydrino atoms with scaled up binding energy spectrum claimed by Randell Mills [?] could be understood if $h_{eff}/h = n$ for ordinary atomics equals to $n = 6$ and hydrino atoms have $n < 6$ [8].

I am not trying to give any summary about various anomalies of water in the following but consider only the above mentioned examples from TGD point of view. Let us therefore make following assumptions (one could represent these assumptions also as questions).

1. Water consists of ordinary and dark fractions. Several values of $h_{eff}/h = n$ are possible and their fractions depend on pressure and temperature. These two fractions can be present in both solid and liquid states. The dark fraction of water - say dark proton sequences at magnetic flux tubes leading also to the notion of dark variant of genetic code inducing the ordinary chemical code [6] - does not interact directly with ordinary water except via classical em fields (this is important!). More generally, phases with different values of n are dark relative to each other. The quantal interactions are only via exchange of dark photons transforming to ordinary photons identified in biology as bio-photons or vice versa. The additional assumption $h_{eff} = h_{gr}$, where h_{gr} is gravitational Planck constant [4, 3], guarantees that the cyclotron energy spectrum of dark photons is universal and corresponds to that for bio-photons (visible and UV) [2].

   The presence of dark protons implies the generation of negative electronic charge. Could repulsive Coulomb interactions become significant and lead to an expansion of water possibly relevant for the understanding of the anomalously low density of ice?

2. Hydrogen bond is thought to be essential for the understanding of the anomalies. Hydrogen bonds could correspond in TGD framework to short and rigid flux tubes. Large values of n scaling up the flux tube lengths would give rise to longer, possibly loop-like, magnetic flux tubes. Indeed, if the total magnetic energy is not changed the string tension defined as magnetic energy density is reduced like $1/n$. Flux tubes could form a dynamical network in which reconnections and phase transitions changing the value of n would make the topology of the network dynamical.

   This kind of flux tube network could give rise to TGD analog of tensor networks [7] realizing quantum entanglement between the nodes of the network and to be central for the formation of gel phase explaining the quantum coherence of water in vivo. The generalization of the usual picture behind bio-chemistry in which one has only molecules to a flux tube network having various particles at its nodes would allow to understand the emergence of complexity in both condensed matter physics and biology [7].

Hydration, dehydration and gel-sol phase transition could involve a phase transition changing the value of n and transforming the hydrogen bonds to longer flux tubes and vice versa. These phase transitions would be also essential in bio-catalysis. It would seem that the natural formulation for various anomalies would be in terms of the flux tube network, whose connectivity depends on temperature and pressure.

3. Dark particles are generated at quantum criticality and quantum criticality could accompany also ordinary thermal phase transitions such as freezing of water.

4. One can imagine several models for the dark fraction of water. Since the temperature range 0-100 °C involves several anomalies, it is natural to assume that the dark fraction of water varies as function of p and T. It seems also safe to assume that the hydrogen bonding becomes maximal at freezing and the bonds identifiable as flux tubes become short. Since the anomalies are strongest around physiological temperature 37 °C, TGD inspired model of quantum biology suggests that dark fraction is highest near this temperature. One expects several fractions with different values of n depending on temperature and pressure.

5. Why water would be so special? Also other liquids could involve flux tubes but with small value of n and therefore much shorter than those in water. Hydrogen bonds in water would also have larger value of n than for other substances. Heavy water does not share the anomalies of ordinary water although the electronic chemistry is the same. The large mass of deuterium probably prevents the formation of dark deuterium. Maybe the fact that the Compton length of (also dark) deuterium is 1/2 of that for (dark) proton could be significant and prevents the formation of dark deuterium bonds?

   Hydrogen bonds are usually associated with electronegative atoms - usually F, O, and N (see `http://tinyurl.com/bntn28n`). Also hydrogen bond between hydrogen and carbon is possible when C is bound to electronegative atoms (chloroform $CHCl_3$ is one example). Note that H_2S, which is chemical analog of water, can form hydrogen with F but two H_2S molecules do not form hydrogen bonds so that H_2S based life is not possible.

2.1 The anomalies in the temperature range 0-4 °C

Consider first a model for what could happen in the range $0-4$ °C under normal pressure.

1. The presence of negative electronic charge induced by the transfer of dark protons to magnetic flux tubes might explain the larger volume of ice as compared to liquid water above 4 °C. The standard explanation is in terms of hydrogen bonds leading to rigid clusters with average distance between water molecules longer than in ordinary water. If hydrogen bonds correspond to short rigid flux tubes these explanations are consistent. The positive charge of dark protons would generate classical Coulomb fields and neutralize this negative charge non-locally as a kind of smooth background so that neutralization would take place in longer length scale and lead to a lower density.

2. What would happen at the interval $0-4$ °C? Do the dark protons at flux tubes assigned to hydrogen bonds transform to ordinary ones and reduce the number of hydrogen bonds and lead to a reduction of the density? Or does the average value of n assignable to the flux tubes increase and increase the average length of flux tubes? Heating would transforms short and rigid flux tubes (hydrogen bonds) to longer and loopy ones. If the magnetic energy is conserved, string tension must scale down by $1/n$ leading to the melting of flux tubes. The melted loopy flux tubes would be longer but their ends could become nearer to each other.

   Melting would thus have a counterpart at the level of magnetic body. Could the freezing of the flux tubes induce the freezing of water? Could the dynamics of ordinary water fraction of water be governed by that of the dark fraction? TGD inspired biology assumes that magnetic body carrying dark matter serves as a template for biochemistry. Could this be true also for thermodynamics?

2.2 Anomalous behavior of specific heat capacity and compressibility

One can try to explain the anomalies of heat capacity in this picture.

1. Specific heat capacity defined as total heat capacity per mass $c_p = (dC_p/dM)$, $C_p = (dE/dT)_p$ at constant pressure. The large value of c_p for water is thought to be due to the splitting of hydrogen bonds by energy feed so that new translational degrees of freedom are created and the energy feed goes to these.

   Could this intuition generalize? Hydrogen bonds would be replaced with flux tube pairs with members carrying opposite fluxes and carrying dark protons and connecting two water molecules. There would be two phases of matter. Lonely water molecules possibly accompanied by short flux loops and pairs of water molecules connected by flux tube pairs. Also clusters of water molecules connected by flux tubes with several pairs of flux tubes emerging from each molecule are possible. Dark matter could be identified the molecule pairs or groups connected by flux tube pairs distinguishing between water and other liquids.

2. The reconnection for a pair of flux tubes with opposite fluxes creates molecules with U-shaped flux tubes, which could rapidly contract. This would lead to two free molecules of ordinary water. These molecules would take most of the feeded energy ΔE and heat the water by ΔT. Also part of the magnetic energy of the flux tubes would be transferred to the kinetic energy of liberated molecules. This energy could be small for short flux tubes at least. If the phase transition increasing the value of n preserves the total magnetic energy, this energy would be small also for long flux tubes.

3. Suppose that the fraction of flux molecules connected by flux tube pairs - dark matter - increases with temperature. c_p is determined by the rate of reconnections of flux tube pairs effectively transforming two dark water molecule pair to ordinary ones. c_p should be reduced above 4 °C up to 37 °C. The value of the latter temperature suggests an increase of dark matter component so that the number of ordinary water molecules would decrease. The first guess is that the magnetic energy is of the order of the bond energy assignable to hydrogen bond and in the range .023-.05 eV. Note that membrane voltage eV corresponds to energy which is same order of magnitude. This interpretation is natural if the creation and annihilation of flux tube pairs is basic mechanism of biology.

   The reconnection creates more ordinary water molecule pairs and only these absorb heat. The absorbed heat is shared between the ordinary water molecules. The energy is shared by a smaller number of ordinary water molecules so that ΔT for given ΔE is higher and c_p is smaller. Note that also the fact that total mass $M = M_{ord} + M_{dark}$ of water is larger than M_{ord} reduces c_p.

4. Why c_p would increase above 37 °C? The most straightforward explanation is that dark matter - that is the molecules connected by flux tube pairs begins to decrease above this temperature. The amount of dark matter - the connectivity of the web formed by flux tubes - is highest at 37 °C. The splitting of the flux tube pairs to pairs of loops would explain disappearance of dark matter above 37 °C. The heat is shared between larger number of ordinary molecules and ΔT is smaller for a given ΔE so that c_p becomes larger. Also the reduction of M_{dark} has similar effect.

Consider next the anomalous behavior of compressibility.

1. The reduction of compressibility K ($\Delta V = -(dlog(V)/dp)\Delta p = -K\Delta p$), which at zero pressure limit is maximal at 45 °C should have an explanation along the same lines. Compressibility is reduced if the increase in pressure produces ordinary water molecules, whose emergence tends to increase the volume filled n by ordinary water molecules. This is the case if the fraction of dark matter decreases with increasing pressure. The reason could be splitting of the flux tube pairs to loops. This predicts that anomalies are absent for high enough pressures as they indeed are.

2. What happens in evaporation? It would seem that the density of dark matter fraction becomes so small that the flux tube connections cannot anymore create the needed cohesion and water evaporates. Note that also the connectivity of the flux tube web is reduced.

2.3 Mpemba effect

What about Mpemba effect (see `http://tinyurl.com/7h2h59p`)? Why hot water would freeze faster than cold water and why the effect would be strongest around 35 °C?

1. The amount of dark matter seems to be essential for the effect. A possible mechanism of freezing would be reduction of lengths of dark flux tube pairs by quantum phase transitions reducing the value of n. This mechanism would contract the flux tubes to hydrogen bonds very rapidly. The resulting ice would serve as seeds inducing the freezing of the ordinary portion of water. Freezing would be fastest around 35 °C.

2. The freezing of dark portion eliminates it. The condition that dark and ordinary portion of water are in kinetic equilibrium could induce the transformation of ordinary matter to dark matter. If this process is fast enough, the freezing could take place via the cycle *ordinary water* $\rightarrow$ *dark water* $\rightarrow$ *ice* and be faster than freezing near freezing point where dark matter fraction is small.

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