A means for liquid water to retain information

Alex Hankey
Swami Vivekananda Yoga Anusandhana Samsthana
Eknath Bhavan, 19 Gavipuram Circle
Kempegowda Nagar, Bengaluru 560019, India
alexhankey@gmail.com

Abstract. The possibility of information storage in chemically pure water is controversial. Storage of digital information is impossible because hydrogen bonds constantly rearrange themselves; specific protons are not stably coupled to specific oxygen atoms. If information is to be stored, its retention must be by other means. Nevertheless, some scientists have contended that information retention in water is not inconceivable, suggesting that water’s microstructure may be involved. The purpose of this paper is to show how these make it possible for water to retain information of a kind different from any previously conceived. Two kinds of entropy can be defined in water, classical due to heat, and quantum attributable to microstates. The method adopted is to compare the two, and to show that the first produces limitations on the second. The number of polymolecules is so vast that the quantum entropy might exceed the heat entropy. Since the classical, heat entropy cannot be exceeded, the number of polymolecules accessible at a given temperature, T, is restricted, yielding a new form of information, I_R(T). The new form of information is entirely different from the four kinds previously known: Fisher Information in Statistics, Digital Information used in IT, Quantum Information, and Experience Information in biological systems at criticality. The new kind of information retained in water is analogous to Fisher Information in that it arises from restriction on the range of a variable, i.e. attributable to limitations on a statistical variable’s values. We therefore propose to name it, ‘Quantum Fisher Information’. Like the process of homoeopathic dilution, which has a limiting temperature around 70°C, Quantum Fisher Information is predicted to have a limiting temperature, T_L. This qualitative agreement is encouraging. Prediction of T_L requires calculating exact numbers of polymolecules. Information retention in water arises from the structure of quantum entropy, and the vast number of possible water polymolecules. Containing both classical and quantum components, the new information is analogous to Fisher Information in statistics.

1. Introduction
Information storage in chemically pure water is a topic fraught with controversy. Storage of digital information is obviously impossible in the liquid because the hydrogen bonds constantly rearrange themselves. Coupling of specific protons to specific oxygen atoms is not stable. If information is somehow to be retained, then such a process must happen by other means. Many scientists and engineers have contended that it is not impossible for water to retain information in some form. India’s visionary

engineer scientist, Rustum Roy [1], in particular, was adamant that information retention in water is not inconceivable. He suggested that the microstructure of water must have something to do with it. It is certainly not explained by other incredibly complex phenomena found in water, particularly in restricted spaces in living cells: polaritons, exciton structures, quantum waves etc. None of those apply to the pure liquid. Water’s microstructure consists of constantly fluctuating polymolecules, of which incredibly vast numbers are available [2], increasing roughly exponentially with each additional water molecule. The purpose of this paper is to demonstrate how these polymolecules can form the basis for the retention of a new kind of information, different from any previously conceived in the physical or mathematical sciences. Its relationship to other kinds of information is discussed at the end, and a name for it proposed.

2. Methods

How can water’s polymolecules form the basis for information retention of a new kind? Their vast numbers are the key to the method adopted here: to consider two kinds of entropy that can be attributed to a body of water, a classical entropy due to its heat content, and a quantum entropy calculated in terms of the numbers of polymolecules. Comparison of the two suggests that the first imposes a restriction on the second, because, despite being potentially very much larger and having the potential to do so, the microscopic quantum entropy cannot exceed the classical entropy. The key to establishing that water does indeed have the capacity to retain information is thus to consider the nature of the difference between these two quantities.

Our method therefore starts with the definition of water’s entropy content. In classical physics, a system’s entropy is defined in terms of a differential change in its heat content. Its value at a given temperature equals an integral over increasing heat content and temperatures, other variables being constant. Classical entropy, \( S_H \), is defined in terms of heat content, \( q \).

\[
\text{d}S_H = \frac{dq}{T} \quad \text{and} \quad S_H = \int_0^T \text{d}S_H = \int_0^T \frac{dq}{T} \quad \text{(1)}
\]

where \( \int_0^T dq \) represents the total heat content of the sample at temperature \( T \), with values of other variables (P or V etc.) remaining fixed.

Note that the statistical definition of entropy, which we now all take for granted, is secondary. Indeed, Boltzmann’s proposal to derive entropy from statistical distributions [3], following Maxwell’s original idea [4] and regard the second law of thermodynamics as one of increasing probabilities [5] created much initial resistance. It led to Boltzmann’s depression and suicide, but was strongly supported by Gibbs [6], and Max Planck [7]. This secondary definition of entropy in terms of the statistics of a system’s microstates is now well established, and must also be considered. The quantum nature of a system’s microstates does not cause an exception; quantum physics contains probability and statistics, so their use causes no conflict. Quantum entropy has separate definitions for states of pure Bosons, given by India’s S.N. Bose for photons [8], and Albert Einstein for single atoms [9], and Fermions, given by Enrico Fermi [10], and Paul Dirac [11]. In our case, the quantum entropy is over a mixture of particles of all different kinds, so the Boltzmann distribution should be used.

The key point is that the secondary definition must yield a value equal to \( S_H \) given by Eq (1), the primary definition. This required equality plays the key role in defining a potential for information content in water: a system’s quantum entropy, \( S_Q \), is defined in terms of a summation over all possible quantum microstates, \( i \), each occurring with a probability, \( p_i \).

\[
S_Q = -\sum_i p_i \ln(p_i) \quad \text{(2)}
\]

For water, the sum \( \sum \) comprises all polymolecule microstates. The way these two definitions affect each other is crucial to the present approach. It leads to the main result.
3. Results
The important point is that: a quantum entropy such as $S_Q$ must reproduce classical laws of entropy change, Eq. (1). In liquid water, the quantum entropy, as defined in Eq (2), consists of a sum over its polymolecule microstates. This leads to a problem apparently not found in other systems. $S_Q$ is potentially far greater than $S_H$. As shown below, the possible structures of polymolecules yield so many microstates that the heat entropy cannot include them all.

The maximum value, $S_{Q\text{Max}}$, of water’s quantum entropy can be $> S_H$, representing the experimental value of entropy? The total number of possible states $S_Q$, Eq (2), or the value of $S_H$, Eq (1)?

In a macroscopic system, the heat entropy, $S_H$, being the fundamental macroscopic property, must represent entropy’s measured value. The meaning of the larger potential value of the quantum entropy, $S_Q$, is that liquid water, despite being dynamically free at a microscopic level, may be unable to explore all of its possible polymolecule structures: because $S_{Q\text{Max}} >> S_H$, the number of different kinds of polymolecule present becomes acutely restricted so that the required equality of the two is maintained, $S_Q = S_H$. The polymolecule $i$ states present in Eq(2)’s $\sum$ cannot include the full range of possible $i$’s.

What can be said about the difference, $(S_{Q\text{Max}} − S_H)$? In other areas of physical science, such a difference represents an information value, usually digital information. Indeed, digital information is often referred to as ‘entropy information’. The difference between the two kinds of entropy can therefore be equated to a kind of information, which can be signified by $I_{\text{diff}}$,

$$ (S_{Q\text{Max}} − S_H) = I_{\text{diff}} $$

a kind of information that may be retained in a body of pure water, i.e. somehow encoded in it. Note that, being a combination of quantum and classical information, $I_{\text{diff}}$ cannot be either of them. It is neither quantum entropy information, nor classical entropy information. $I_{\text{diff}}$ represents a new kind of information that water is able to retain, so we shall denote it by $I_R$. Furthermore, the heat entropy, $S_H$, depends on temperature $T$, so $I_R$ is a function of $T$, $I_R(T)$.

Hence, an astonishing new result: information retention is possible in pure water, where the information retained, $I_R(T)$, is defined as:

$$ I_R(T) = I_{\text{diff}} = (S_{Q\text{Max}} − S_H(T)) $$

How such information can be used, and what it can encode are the next questions to consider.

4. Discussion
The method utilized to obtain this unusual result is not really new. In statistical mechanics and thermodynamics, the classical, heat entropy always leads to restrictions on the microstates of the physical system concerned. Restrictions are the norm. Distributions of microstates are calculated directly from the primary, heat entropy. In both classical and quantum physics, the entropy derived from system microstates is required to equal the heat entropy. The classic result of exponential decay of state occupancy with energy [3-7] follows from it, so do the related quantum forms for bosons [8,9] and fermions [10,11]. The novel aspect of formula, (3b), is that it leads to a way that a body of water can retain information. To what does such information refer? To its previous states! As we now show, this follows because both initial and subsequent states necessarily contain limited but related selections of polymolecules.

$I_R(T)$ as Information Retained about Previous States: Consider what happens when, starting from pure water created by, e.g. distillation, a body of water has a chemical dissolved in it. The solute will alter the balance of polymolecules. Owing to subtleties of its structure seeding new possible polymolecules, and their enormous variety, the selection of polymolecules will be specific to the chemical; such is the vast measure of available information, $S_Q − S_H$. This result will also apply to further chemical changes. Each change will produce a specific mixture of polymolecule states. After a given sequence of changes, the final state will effectively retain information about the sequence! For this
reason, the entropy difference, \( I_{\text{diff}} \) in Eq(3a), can be equated with a capacity for polymolecule structures in water to retain information about previous states, Eq(3b). \( I_{\text{R}}(T) \) therefore presents a Means of Information Retention in Water, a.k.a ‘Water Memory’. In other areas of science, such a kind of statistical limitation is considered a kind of information.

Currently four kinds of information are recognized in the scientific literature. The first was Fisher Information in Statistics [12,13], which arises when variance restricts a variable’s range. If a variable has a particular distribution of values over a given range, then lower variance increases the amount of information yielded by the distribution. Second is information technology’s Digital Information [14,15], often called entropy information [16], with which we are all familiar. Quantum Information [17,18], applying to quantum systems, normally defined in terms of the Von Neumann entropy [18], is the third, while the fourth is Experience Information [19-21], found in biological control systems when correctly functioning with their loci of control at critical instabilities (the condition known in complexity biology as ‘criticality’).

The new kind of information proposed here in Eqs (3a) and (3b) has properties parallel to the first three of these. Like Fisher Information [12], it depends on the restriction of the statistical range of a variable, in this case the number of kinds of polymolecules. Similar to Digital Information, which is equivalent to a kind of entropy, and often known as ‘entropy information’, it is closely related to system entropy. As we have seen, \( I_{\text{S}} \) also directly encodes information, and is parallel to that property of digital information, which Claude Shannon discovered [14,15] by analysing how different forms of encoding by different means of encryption could be equivalent to each other. It also relates to the concept of quantum information given by Von Neumann [18], in that it involves a measure of the quantum microstates of the system. Considering all the above, especially that the new kind of ‘information’ is retained due to limitations on the value of quantum entropy in water, it seems most closely related to Fisher Information.

We propose \( I_{\text{R}}(T) \) be named ‘Quantum Fisher Information’. A pertinent aspect of Quantum Fisher Information is, according to the definition, it may only be possible below an upper limit in temperature. Clearly, water’s maximum possible quantum entropy \( S_{Q} \) is fixed by its possible polymolecule structures, but the classical heat entropy, \( S_{H} \), is always increasing. Might there not be a temperature where the second becomes larger than the first? Then the phenomenon would not be possible.

An important application of ‘water memory’ is to homoeopathy. Indeed, that was the original reason for developing the theory [1]. Homoeopaths’ say that processes of succussion and dilution become ineffective when performed in water above a temperature of about 70°C. Such an upper temperature limit is easily understood, at least qualitatively, since our analysis requires that the quantum entropy, \( S_{Q} \), be larger than the heat entropy, \( S_{H} \). That would only hold when the number of polymolecule states is large enough. If the increase in heat entropy with increasing temperature causes \( S_{H} \) to become equal to \( S_{Q} \) and then to exceed it, then \( I_{\text{R}}(T) \) has no entropy available to retain information, and the phenomenon cannot occur. It also predicts a value for \( S_{Q} \): \( S_{Q} \approx S_{H}(T=70) \), which is in principle testable by computer modelling. The specific entropy \( S_{S} \) of a system of \( N \) states, each of probability \( p_{i} \) is given by a sum over states:

\[
S_{S} = \sum_{i} N^{N} p_{i} \ln(p_{i})
\]  

When all the \( p_{i} \) values are equal, we obtain,

\[
S_{S} = -N \left( \frac{1}{N} \right) \ln\left( \frac{1}{N} \right) = \ln(N)
\]  

In the case of water polymolecule clusters, \( N \) is vast. For each water polymolecule containing \( n \) water molecules, the last molecule can be added in roughly \((n-1)\) places. Thus, the number \( N(n) \) of water polymolecules with \( n \) component water molecules can be estimated as

\[
N(n) = (n - 1)!
\]
The number of possible water polymolecules is therefore given by summing this up to a limiting $n$, 

$$N = \sum_{n=1}^{\infty} N(n) = \sum_{n=1}^{\infty} (n - 1)!$$  \hfill (5c)

We can therefore predict that Quantum Fisher Information in water has a limiting temperature, $T_{\text{Max}}$, for which $I_R(T_{\text{Max}}) = 0$, due to limitations on the rate at which numbers of polymolecules grow with increase of their number, $n$, of component water molecules. Homoeopathy’s qualitative agreement with our analysis is encouraging. Precise prediction of $T_{\text{Max}}$ would require calculation of exact numbers of polymolecules for high values of $n$. Equation (5b) suggests that even a good estimate of the logarithmic increase in number, $N(n)$, of polymolecules for increasing values of $n$ would yield a crude estimate.

5. Conclusion:
Information retention in water is possible because of the structure of quantum information, and the vast numbers of water polymolecules present in the liquid. It is due to limitations on water’s quantum entropy, which ‘saturates’ because it cannot exceed water’s classical heat entropy. It is a quantum analogue of Fisher Information in statistics.

6. Summary
The proposed explanation of ‘Information Retention in Water’ is very simple: because of its microscopic properties where hydrogen bonds connect create large polymolecular associations, two kinds of entropy can be defined in liquid water, (1) the classical heat entropy, $S_h$, which is the actual entropy, and (2) a quantum entropy due to water polymolecule clusters, $S_Q$. A conflict then arises, because $S_Q$ is potentially far larger than $S_h$, but in actuality cannot exceed it.

At low temperatures, the quantum entropy’s maximum possible value, $S_{Q_{\text{Max}}}$, is far larger than the classical entropy. The quantum microstates are therefore unable to form a quantum mixture of all their possible forms at any one time. The difference between the two entropies, $S_{Q_{\text{Max}}}$ and $S_h$, constitutes a measure of restrictions on water’s polymolecular microstructures.

Ronald Fisher recognised that a degree of restriction on a number of statistical possibilities constitutes a form of information. The difference between the two entropy values, $S_{Q_{\text{Max}}} - S_h$, can be interpreted as a form of ‘Fisher Information’ available in the water – a form completely different from all forms of information previously defined – the original Fisher information, digital information, quantum information, and experience information. To distinguish it from those, it needs its own name. I propose, ‘Quantum Fisher Information’.

How can such information be used in practical terms? At any one time, a given body of water will be in a quantum state comprising a specific selection of polymolecule microstates. The selection of microstates will be altered by each process undergone by that body of water; they will yield different selections of microstates. Its microstates thus enable water to record and retain information about each process. They constitute a kind of memory. Similarly, a sequence of processes will also lead to different selections of microstates, which therefore present quite a complex memory capacity.

The entropy difference, $S_{Q_{\text{Max}}} - S_h$, can thus be considered a measure of how much information is available in that body of water for encoding histories of events in its immediate past. This available information, defined by $S_{Q_{\text{Max}}} - S_h$, was named $I_R$. This paper has referred to $I_R$ as ‘retained information’ with the ability to quantify the phenomenon of ‘information retention’ in water. Since it evidently refers to sequences of past events in the water, it might also be loosely referred to as a capacity for ‘Water Memory’.

More precisely, because $I_R$ presents a means by which its history of previous states can be embedded in a water sample, it implies in and of itself that different polymolecule selections can be present in the water sample; the precise selection linked to details of processes that the sample has undergone, thus representing a ‘memory trace’ of those processes.

Thus, the Information Retention capacity, $I_R$, acts as a water memory. As long as $S_{Q_{\text{Max}}} > S_h$, $I_R$ offers a rigorous explanation for water memory associated with Homoeopathic Succussion. As temperature
rises to about 70°C, homoeopathic dilution is said to become ineffective. Such a limiting temperature $T_{\text{Max}}$ can be explained by $S_H$ increasing in value and becoming equal to $S_{Q\text{Max}}$. At the temperature, $S_H = S_{Q\text{Max}}$, and $I_R$ equals zero, i.e. $I_R(T_{\text{Max}}) = 0$.

Another interesting aspect of $I_R$ is that it is presently limited to water and its dilute and ultra-dilute solutions. Now that water’s information retention capacity is theoretically understood, however, variations on it should be practically explored. It can occur in any liquid, molecules of which can associate into large clusters of ‘polymolecules’. If those clusters are sufficiently rich in possibilities, the laws of quantum statistical mechanics will exert restrictions resulting in a capacity for Quantum Fisher Information, i.e. some form of ‘information retention’.

References
[1]  Novella S, Roy R, Marcus D, Bell I, R, Davidvitch N and Saine A A 2008 Debate: Homeopathy—quackery or a key to the future of medicine? Journal of Alternative and Complementary Medicine 14 1 9–15
[2]  Chaplin MF 2007 The memory of water: an overview Homeopathy 96 3 143–50 See also: Chaplin M 2011 Water structure and science
[3]  Boltzmann L 1868 Studien über das gleichgewicht der lebendigen kraft zwischen bewegten materiellen punkten Wiener Berichte 58 517–560
[4]  Maxwell, J C 1860 Illustrations of the dynamical theory of gases Part I On the motions and collisions of perfectly elastic spheres Philosophical Magazine, 4 19 19–32
[5]  Boltzmann, L 1974 The second law of thermodynamics Populare Schriften, Essay 3, address to a formal meeting of the Imperial Academy of Science, 29 May 1886, reprinted in Ludwig Boltzmann, Theoretical physics and philosophical problem, S G Brush Trans. Boston: Reidel
[6]  Gibbs J W 1902 Elementary Principles in Statistical Mechanics New York: Ch Scribner's Sons
[7]  Planck M 1896 Gegen die neure energetik Annalen der Physik 57 72–78
[8]  Bose S N 1924 Planck’s gesetz und lichtquantenhypothese Zeitschrift für Physik in German, 26 178–181
[9]  Einstein A 1924 quantentheorie des einatomigen idealen gases Akademie der Wissenschaften, in Kommission bei W de Gruyter
[10]  Fermi E 1926 Sulla quantizzazione del gas perfetto monoatomico Rendiconti Lincei in Italian 3 145–9 trans. A Zannoni 1999 On the quantization of the monoatomic ideal gas (arXiv:cond-mat/9912229)
[11]  Dirac P A M 1926 On the theory of quantum mechanics Proc Royal Soc A 112 762 661–77
[12]  Fisher R 1925 Statistical Methods for Research Workers Edinburgh: Oliver and Boyd
[13]  Frieden R 1999 Physics from Fisher Information Cambridge University Press, Cambridge
[14]  Shannon C E 1948 A mathematical theory of communication Bell System Tech J 27 379–423
[15]  Shannon C E 1948 A mathematical theory of communication Bell System Tech J 27 623–656
[16]  Brillouin L 2004 Science and Information Theory Courier Dover Publications
[17]  Ban M 2006 Decoherence of continuous variable quantum information in non-Markovian quantum channels J Phys A: Math 1939 1927
[18]  Von Neumann J 1932 Mathematische Grundlagen der Quantenmechanik Berlin: Springer; English Trans. 1955 Mathematical Foundations of Quantum Mechanics Princeton Univ Press
[19]  Hankey A 2014 Complexity biology-based information structures can explain subjectivity, objective reduction of wave packets, and non-computability cosmos and history J Natural and Social Philosophy 10 1 237–250
[20]  Hankey A 2015 A complexity basis for phenomenology: How information states at criticality offer a new approach to understanding experience of self, being and time J Prog Biophys Mol Biol 10 237–250
[21]  Amoroso R L 2004 Collective modes of ordered water as a synchronization backbone for quantum neuromolecular computation and consciousness Noetic J 4 4 370–376 (Preprint, http://vixra.org/pdf/1305.0109v1.pdf)