Anticipation and Meaning

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Abstract. "Can we truly compute, until we understand what information really is?" *Gordon Scarrott*. A new, mathematically described understanding of physically meaningful information, quantum holography, concerning actual knowledge of the 3 dimensional physical world in natural systems, is proposed. It is based on demonstrably proven anticipatory quantum mechanical laws and the new awareness in quantum theory. This understanding concerns a form of information, which holography shows, almost certainly existed before the origination of living systems and even from the beginning of the cosmos. It produces physically realisable mathematical definitions of the concepts of information, knowledge, learning, intelligence, perception, cognition, etc. Some of its other many advantages are cited. In particular, being quite distinct from bits, which are simply physically realisable mental models for the carriage/transmission of symbolic data (dependent for its meaning on human interpretation) it is not, its mathematical theory indicates, subject to the processing limitations of the combinatorial explosion governing algorithmic complexity, or to the known processing limitations of formal systems, such as the Halting Problem, as they are thought to apply to classical digital computing systems.

Keywords: anticipation, information, physically meaningful, quantum holography, phase conjugation.

1 INTRODUCTION

"Can we truly compute, until we understand what information really is?" Gordon Scarrott.

Could Scarrott [1986] be right? For as will be shown, the understanding of the nature of information is incomplete. It does not simply concern what Shannon dealt with, namely the efficient carriage/transmission, etc of signals, although this is, of course, a very important part of that understanding. For as the dictionary tells us, information informs. It therefore holds an intrinsic meaning or message, which relates to some fact, model or 'form', the last being the root from which the word information is derived. Implicit in the concept of information is therefore the notion of the communication of meaning as a reciprocal transactional process between two or more communicants. Here the key root words concern what these communicants have 'in common' as this relates to such facts, forms or models. Thus it seems that meaningful communication is anticipatory and comes about as consequence of the ability of the receiving communicant's model to predict the meaning which the other communicant is attempting as a prediction of its model to transmit, and vice versa [Dubois 1997, 2000].

But all forms of physical illumination/beam have a natural ability to hold an intrinsic meaning or message. For following the incidence on an object of such illumination, it becomes, as holography proves, an 3 dimensional object image bearing beam. That is to say, the beam, like a radio/ television signal, is a form of wave but carries in this case, the 3 dimensional spatial 'form' of actual objects, which is actual knowledge or fact about the world i.e. intrinsically meaningful information. The ability to meaningfully communicate may therefore, as shown below, be defined in terms of the processes of quantum holography [Schempp, 1992]. This describes (see 3.2) how to receive/encode, decode/transmit, store and filter, etc, holographic information in the form of patterns/generalised holograms, which may each encode an object image bearing beam itself, i.e. the 3 dimensional object image in the context of its wave.

Quantum holography works in accordance with the transactional interpretation [Cramer 1986; 2000] employing quantum mechanical advanced and retarded waves, [Dubois 1999;1998] see 3.3. It is therefore a demonstrably anticipatory information processing paradigm and a means by which anticipation can be physically realised.

Quantum holography, see 3.2, concerns the new awareness that exploitation of interference effects inherent in quantum mechanical systems can be used to guide their evolution, see 3.1.

In addition to explaining how magnetic resonance imaging, tomography [Schempp 1998; Binz and Schempp 1999; 2000 a,b] and microscopy, work (see http://wwwcivm.mc.duke.edu), it is postulated as the explanation of how our senses extract the meaning necessary for our survival, from the streams of information with which they are continuously assailed.

Since in holography, information is carried by waves rather then by bits, this again raises the question of what information really is.

2 INFORMATION

2.1 What is Information?

Information, as used in natural systems, need not consist of bits, as in the classical computer science of the ubiquitous digital computer. For bits and indeed qubits (the quantum mechanical analogue of bits) are simply, physically realisable mathematical /mental models for the carriage/transmission of symbolic data. This is even the case for numbers, which are symbolic, often approximate representations (according to some arbitrary radix) of physical or mental magnitudes (i.e. number!), to which the algorithms of ordinary arithmetic, addition, subtraction, etc (often implemented in the logic of the computer hardware, but which could just as well be software) apply. Such symbolic data may or may not convey any meaning and is subject to the processing limitations of algorithmic complexity, of formal systems, such as Godel's theorem/the Halting Problem/errors and paradoxes of type, etc, as well as the well known difficulties of devising complex algorithms, programs, and of validating the correctness of the corresponding software. These difficulties all arise from the need to have an agency -ourselves- to assign meaning to the symbols, if their processing is to have any practicality, a little understood process, which requires what we call intelligence [Marcer, 1997]. *We must therefore ask ourselves, how is it that our biological brains are able to assign meaning, when digital computation (without our aid) cannot.* One explanation could be that information in use in natural systems (with the possible exception of human brains) is, as a consequence of natural selection, not mathematical and symbolic, but intrinsically physical and meaningful, so that, as is shown below in 3.2B in relation to quantum holography, the property analogous to the combinatorial explosion of algorithmic complexity can be overcome. That is to say, information in natural systems is not analogous to currency, which merely symbolises wealth, but is analogous to wealth itself, i.e. it concerns meaning per se, and that this is the reason why nervous systems are so much more versatile, competent and efficient in relation to cognition than the artificial intelligence of digital computers.

2.2 What Form of Information Might Matter and Energy Produce**?

This perspective** must now be taken, because since the discovery by Deutsch [1985] of the universal quantum theory of computation, this quantum physical theory, replaces Turing's mathematical/mental theory of computation, which it includes, as the basis of the description for information processing. It strongly suggests that quantum physics is essential to the implementation/execution of all mathematical thought, since information in physical systems, arises in the form of signals as the result of quantum measurement [Marcer, this conference], so that universal quantum information processing could explain the undue effectiveness of mathematics in describing physics [Chapline 1999].

Another form of information therefore concerns, for example, that of the physical 3 dimensional properties of objects, which the physical processes of quantum holography show, consists of actual physical patterns of particle/wave energy. These patterns exist for all forms of physical illumination, be it electromagnetic, acoustic, etc, following that illumination's incidence on the objects in question. Such generalised holographic data as particle/wave energy (such as will have existed prior to any mental model i.e. human agency and by implication the origination of all life!) is actual knowledge (with respect to the properties of the illumination) about 3 dimensional objects and their 3 dimensional positions relative to one another. These physical patterns, can, the physical processes of holography tell us, be encoded and decoded, into and from holograms. This physical encoding of the whole of the 3 dimensional object image bearing illumination itself, concerns, the experimentally validated mathematically described models of

holography now tells us, the local amplitudes and phases of the illumination, which are both needed to enable full wave front construction encoding, or decoding. Magnetic Resonance Imaging (MRI) machinery [Schempp,1998] and it has been hypothesised DNA [Marcer, Schempp, 1996; Clement et al, 1993], cells [Marcer, Schempp, 1998a], neurons [Marcer, 1992; Marcer Schempp, 1997], brains and their sensory apparatus [Pribram, 1991; Schempp, 1992; Marcer, Schempp, 1998], all employ quantum holography, with the ability to use the whole of the information/meaning 'encoded' in sensor illumination, i.e. both amplitudes and phases. Such a form of encoding would convey a definite evolutionary advantage. It requires reversible phase rather than bit gates [Sutherland, 1999; Marcer, Schempp, 1998], for otherwise half the information, the phase, arriving at, say, a sensory apparatus, will be lost or must be, in some other way, reconstructed. In this way, it is possible, for example, with a single encoding/decoding, to reconstruct in a single action, the whole physical 3 dimensional wave front of the 3 dimensional reality on which the illumination arriving at the sensory apparatus was previously incident, before the whole of this holographic information is passed on and accumulated to constitute the basis of an every increasing discriminatory holographic record as an associative memory/filter bank of the machinery's sensory experience of reality [Marcer, Schempp, 1998]. That is, such machinery, if it can be built or already exists in biological systems, would have a memory which naturally learns by experience, recorded in terms of the unique real time history of the system's sensory three dimensional holographic knowledge of the real world. Such machinery utilising quantum holography, which incorporates signal theory into quantum physics [Schempp, 1986], when mathematically modelled, it can be shown,

a) is potentially capable of dealing with exponential or even exponential towers of complexity [Marcer, Schempp, 1998; Marcer, 1997] see 3.2 B ; capabilities, which, as far as is known, are beyond digital computers,

b) possess, as shown in the references cited above with respect to the models of DNA, a cell, a neuron, and the brain as a whole, the basic 3 dimensional morphologies of their corresponding biological counterparts, and

c) includes a natural condition, phase conjugation, by means of which context dependent symbol manipulation (of which digital computation is a subset) can be realised, see 3.4.equation (1)

3 QUANTUM HOLOGRAPHY

3.1 The new Awareness in Quantum Mechanics

There is a new awareness that quantum interference effects (in this case, attributable to quantum holography specified in terms of the Heisenberg group G [Schempp, 1986; 1992]) inherent to the quantum mechanical description of systems, can be used to guide their evolution [Rice, 1992; Schleich, 1999]. This arises, for example, from the new science of quantum information processing and communication [Sudbery, 1997; Bouwmeester et at., 1997] and recent discoveries in quantum chemistry [Judson, Rabitz, 1992; Dahleh M et al., 1990].

Further, while the Heisenberg uncertainty principle forbids assigning both a well-defined position q and momentum p to a quantum system, say an electron, it is possible to completely determine the state of a quantum mechanical system in the form of the Wigner function or whole distribution of position and momentum values for the electron, see Leichtle et at, [1998], where this example of an experimental validation is described as “quantum state holography”. Similarly in quantum holography specified in terms of the Heisenberg Lie group G, as used by Walter Schempp[1999] to describe magnetic resonance imaging (MRI) systems. Here quantum holographic encoding/decoding concerns full wave front reconstruction and quantum measurement /output is the result of a resonant exchange of energy, where the parameters are chosen so that this exchange is reversible. In fact, in MRI, spin echo control techniques [Schempp, 1999] have been developed to provide full wave reconstruction over a whole range of scales, so that images with high degrees of resolution across the range are rapidly achieved.

3.2 Quantum Holography as Specified by the Heisenberg Lie Group

A. Quantum holography allows the position and momentum of systems as governed by the quantum mechanical commutation relation $q.p - p.q = ih$ to be expressed as a Lie group-theoretical construct, i.e. as a complete distribution of the position and momentum values q and p respectively, appropriate to the quantum interference effects necessary for holography, such that there is full wavefront reconstruction.

This Lie construct [Schempp, 1986] concerns {P,Q,Z} the canonical matrices of the Lie algebra g of G, which Weyl

discovered define the quantum system's uncertainty in terms of the standard deviations of the self-adjoint operators in complex Hilbert space. It provides an abstract mathematical means to express the generalised position and momentum of the whole system, as Q and P respectively, leading to a signal, which is that of the full wavefront reconstruction, described in terms of Z, such that

$$[P,Z] = 0;\ [Q,Z] = 0;\ \text{and}\ [P,Q] = PQ - QP = Z,$$

define the Heisenberg commutation relations.
Thus, quantum holography [Schempp, 1986] incorporates generalised holographic signal theory into quantum physics, specifying not only quantum interferences as quantum holograms that can be encoded and decoded [Schempp, 1992], but also the quantum transmission of holographic signals, involving both luminal and supraluminal modes (i.e. quantum teleportation) [Schempp, 1992; Sudbery, 1997; Bouwmeester, 1997].

B. It defines the exponential map exp g = G, [Schempp, 1992], which is the Lie diffeomorphism of the Heisenberg Lie group G. This differentiable map having a differentiable inverse, the corresponding logarithmic map, shows how, in principle, any combinatorial explosion of exponential complexity can be overcome. And it is this exponential diffeomorphism which Binz and Schempp, [1999], have shown, differentiates quantum from classical holography.

C. Thus, in this particular case, Heisenberg uncertainty is not an obstacle to holographic information processing. Indeed it facilitates it! For the quantum mechanical propagator $U = \exp(i\, d\varphi) = \exp(i\, Hdt)$, can now be given the interpretation of a computational gate. That is, one where i is $\sqrt{-1}$, $d\varphi$ is a change of phase, and H is the quantum Hamiltonian or energy operator such that dt is the finite time interval or "clock period" at the end of which the energy H applied to the gate, is turned off. This shows that quantum holography turns the previously held meaning of quantum uncertainty on its head, since it has now become the actual means by which to compute.

It leads to the conclusion, for example, as is now demonstrated conclusively by nuclear magnetic resonance and MRI, or in the laboratory for chemical reactions, that optimal control can be exercised over uncertain quantum systems, and that, as described by the exponential Lie diffeomorphism of G, this is possible in realtime [Rice,1992; Dahleh et al, 1990; Judson et at, 1992].

D. Further P and Q allow the definition of complex mode co-ordinates

$$R = 1/2(P+iQ);\ R^* = 1/2(P - iQ)$$

[Schempp, 1993], which permit the description of the different alternatives at, say the photon level, that can co-exist in quantum complex linear superposition, in terms of the annihilation a and creation a* operators of an emitter/absorber (Fock) model, where the number states $|N_k\rangle$ are the quantum states with n_k quanta occupying the mode k. In such models, $N_k = aa^*$ and $[a,a^*]$ is the bosonic commutation relation, which maybe interpreted as expressing the quantum interference of the system, in terms of "the squeezed states" of the photons [Schliech and Wheeler, 1987; Marcer, 1992].

3.3 A Description in Terms of Advanced and Retarded Waves

Thus if holographic transform $H_\nu(\psi,\phi; x,y)$ expresses the probability of detecting a quantum of energy, frequency ν, within a unit area attached to the point (x,y) in the hologram plane, where wavelet mixing in terms of the wavefunctions ψ and ϕ takes place, then $H_\nu(\psi,\phi; ..)$ and its contragredient representation $\underline{H}_\nu(\psi,\phi; ..)$ respectively determine the wavelet transform of the retarded signalΨ with respect to the advanced reference response wavelet ϕ and vice versa, such that the time averaging performed by superposition of the net wavelets by integration along the real line R (which is expressed in the modular scalar product $\langle\ \rangle$ of the complex Hilbert space $L^2(R,dt)$) effectively freezes the time t of the advance signal wavelet packets and the retarded response wavelet packets into the spatial synchronisation variables (x,y). Thus this spatial encoding of the relative phases avoids the loss of phase information under wave packet reduction and knowledge of the co-ordinates (x,y) with respect to the symplectic frame, they determine, allows identification of the split quantum channels in accordance with the non-local quantum property of individual quanta passing by different pathways. That is, locally recording (x,y) makes the multiplexing coherent wavelet packet densities $\psi(t')dt'$ and $\phi(t)dt$ indistinguishable by relative time and phase corrections to the respective pathways. This conservation of information on wave packet reduction is the truly remarkable feature of quantum holography and of gating this way by phase. It would allow an organism or a brain/mind to function as a fully

distributed synchronously partitioned massively quantum parallel information process/processor.

3.4 The Importance of the Condition of Phase Conjugation

Such machines would and do, in the case of MRI, allow, quantum holography says, 3 dimensional wavefront reconstruction in accordance with the conditions {P,Q,Z}, employing, say, a sensory apparatus utilising holographic phase conjugate adaptive resonance. That is to say, such a sensory apparatus performs as an active phase conjugate mirror, such that the wavefront reconstruction of the 3 dimensional virtual or real object imagery coincides with that of the 3 dimensional objects themselves. Classical active phase conjugate mirrors are already in use in weapons systems.

This condition is of fundamental importance in quantum holography, because it produces an adaptive resonant signal *i.e. effectively an amplification* allowing detection [Schempp, 1998]. It might be objected that, for example, the brain including its sensory apparatus, does not employ phase conjugation. However two simple perceptual experiments serve to show that it does

a) snap one's fingers and ask where the brain creates the acoustic image of the snap. It is outside the head, *coincident with the snap,* as a phase conjugate image must be; similarly

b) reach out for a nearby object and touch it. Not only do the visual and tactile object images the brain creates, each coincide with the object, but this coincidence also occurs *outside the head in every 3 dimensional geometric particular* with reference to the scale of resolution of which the senses are capable, as it would be the case in holography.

The condition of phase conjugation must be of vital importance to the processes of image formation in the brain of the imagemaker, since the survival of the imagemaker is completely dependent on locating objects where they actually are, whether it be by vision, sound or touch or even by taste or smell; that is, of sensing the world “the way it actually is”. Such a statement in “...“ is fully justified since, for example, the use of touch (where the tactile object image phase conjugately coincides with the object) invokes an opposing reaction to any action or vice versa - an essential criterion of experimental science.

Phase conjugation is also essential to communication between image makers. For what an imagemaker cognises objects to be, depends entirely on the imagemaker's history of experience. This history is unique, since each imagemaker follows its own unique position or world line of motion and no two histories can be exactly the same. However what such imagemakers share in common on their own scale, is the objects of that scale and their positions relative to one another in the Cartesian theatre the objects define.

Thus, according to this model, bats see acoustically “the same 3D geometric reality” we see visually but they attach totally different meanings to the objects seen, as a result of their different genetic constitution, sensory apparatus, and their individual history of experience. Quantum holography therefore provides a clear definition of objectivity and subjectivity with respect to the qualia/properties of objects, where it is the objects themselves, that implicitly label all aspects of experience in a universal way for all observers on that scale. Objects, the observed, therefore provide an implicit common labelling as the basis of communication between such observers with a common genetic heritage and sensory apparatus. It predicts therefore that human languages are to be defined as shared arbitrary labellings of objects, where their properties are such that

each holographic encoding of an object	<----------> maps to and from	the holographic encoding of the arbitrary label for that object.	(1)

Thus it can be postulated that the morphology of the human brain contains an instantiation of such mappings [Marcer, Schempp, 1998]. That is, the two brain hemispheres and corpus callosum (which joins them) are, where these encodings reside and the maps (to and from) are realised. In this case, the right hemisphere containing the holographic encodings of the real world would be the artistic/geometric brain, and the left, containing the arbitrary labellings for the real world objects and their properties, the logical brain. In the latter, an essential element of such a labelling of objects includes numbers and sets and their logical relationships/mappings one to another, where now these must be acquired by learning/adaptation. Thus in quantum holography, phase conjugation defines the mappings necessary to both geometry and logic, providing the canonical labelling any model of information processing must have if it is to formally and correctly constitute computation. For without such a canonical labelling, paradoxes and errors of type will inevitably occur. This also says, brains would possess a complete hemisphere, the right, (plus a mapping morphology, the corpus callosum, to the left or 'digital/logical' hemisphere) absent or at best only

simulatable by digital systems, as well as its quantum information processing capabilities, This says, that in the human brain, it is the right artistic hemisphere and the corpus callosum, that effectively overcome the limitations, like Godel's theorem, of the formal systems “encoded” in the left hemisphere, which includes the analogue of the digital computer. Correspondingly quantum holography predicts:-

a) that the surface of these hemispheres i.e. the sensory cortices are, hologram planes, where the holographic sensory data is encoded and decoded, such that the brain itself is a phase conjugate resonant cavity,

b) that the eye is also such a phase conjugate resonant cavity, where the retina is the hologram plane containing an array of detectors working by phase conjugation. Thus it will appear to the eye/brain as if the real phase conjugate incoming object image bearing beam, is an actual (rather than the virtual phase conjugate) outgoing beam, which coincides with the object or objects from which the sensory signal originates, as was originally proposed by Plato, and as pointed out in the simple perceptual experiments already described, and

c) that there must exist a quantum physically real, 3 dimensional holographic virtual image of the individual or self, able to produce real physical effects as the result of measurement. That is to say, the individual will be describable quantum mechanically by a state vector, i.e. in terms of complex amplitude with a geometric phase [Berry 1989; Resta 1997] and quantum observables which are gauge invariant phases. The existence of such a self would therefore have radical consequences not just for brain science but for all biological systems and medicine. For is not health defined as making whole, and do we not say when someone is unhealthy, “that they are not themselves today”. That is, to say the physical body is out of tune with its self or whole (now described by a complex amplitude), which thus can be postulated to perform the function of the template for the immune system, if the individual's health as a whole is to be restored. For in terms of quantum holographic measurement theory, the self would be the means of calibration against which each individual measures themselves. As Shakespeare said, "to thine own self be true, and it must follow like the night, the day, thou canst not then be false to any man".

4 CONCLUSION

These facts and extensive other evidence to be described/cited, lead me to conclude that Nature has already evolved such machinery, namely biological systems, including ourselves, and that biological brains are vastly more versatile, competent and efficient than the artificial intelligence of their digital counterparts. This belief stems from the fact that generalised holography enables physically realisable mathematical definitions, of what information/ knowledge (as explained above), intelligence [Marcer, 1997] , sensory perception and cognition [Marcer, Schempp, 1998], etc may truly be.

It could explain why the high expectations of digital computer scientists with respect to artificial intelligence and robotics, remain merely speculation and hype, and will remain so, since any robotic acts by digital or even qubit machines, necessitate the conversion of data from the exponentially complex real world into bits or qubits for processing before being converted back; cumbersome input/output operations, which place practical limits on such symbolic computational machinery (however fast), compared to those of their quantum holographic counterparts. It would also account for the fact that there are no known naturally evolved machines, working by the extremely simple symbolic modus operandi of digital computation; machines that would almost certainly be expected to exist, if such machinery could become so rapidly potentially more intelligent than ourselves, as is often now presaged. This says that the secret of brains is not their processing speed, but their efficiency, versatility and the fact that they process meaning attuned to the 3 dimensional world in which they exist. The theoretical physics of the quantum holographic model also shows [Clement et al 1999; Marcer 1992,1992a] that in biological neurons/cells,

i) that a network of, say, ions on, or corresponding 'holes' in a biological membrane, possessed by a single biological neuron, or in a cortex of such neurons, can function as a Hopfield and Tank [1987] neural net of very great complexity, or

ii) that since such an ion possesses quantum mechanical spin, or the corresponding hole, a quantum mechanical occupation number, that such an ion or hole could function as a universal quantum computer carrying out a perfect physical simulation in the sense of Deutsch [1985], within a quantum parallel network of such computers [Deutsch, 1989]. If these capabilities, comprising functioning human brain networks of , it maybe estimated, some 10^18 nodes or universal quantum simulators, are realisable, then we can only gaze in awe at Nature's evolutionary triumph of technology!

These conclusions all indicate, as quantum computation does, that the unification of physics involves the understanding of what information is and how information in nature is incorporated into natural law. An

incorporation, which will, I am sure, radically change our understanding of the natural world, in 21st Century. In particular, if each living system, and in particular each human individual is, indeed, a macroscopic quantum system or whole, [Marcer, Schempp, 1999] then each will correspond to a description by an individual quantum state vector. Such vectors are not only then complex quantities obeying quantum mechanical laws, such that observables exhibiting eigenvalues will exist, but each will concern observable gauge invariant phases in relation to a geometric phase [Berry, 1989;Resta, 1997]. Thus it can be postulated that state vector of the individual as a whole defines an individual, as a body/brain/mind, mathematically specifying a set of physically realisable of gauge invariant phases of its geometric phase, where these constitute respectively the mindset of its mind, such that mental events cause neural events and vice verse [Eccles,1986; Marcer, Schempp, 1998]. This overcomes the usual arguments that postulating a homunculus, the mind, implies an infinite regression. For in this case, the homunculus corresponds to the quantum mechanical mathematically specified virtual part of the individual as a 3 spatial dimensional whole [Marcer, Schempp, 1999], resulting in real observable physical consequences, and so may itself be considered as physically real.

This new explanation of information is not at odds with the current classification used in computer science, namely syntactic, semantic and pragmatic. For syntactic information remains rule based, while semantic information, the model above says gives rise to meaning that is an anticipatory finality, and that the pragmatic is context dependent information, such that the anticipated events depend strongly on the configuration of the quantum system as a whole.

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