Hypercomputation

Cybernetic Machines, Past, Present, Future.
How my Thinking has been Shaped!

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Abstract

At the end of the last century, Planck opened the door onto the quantum mechanical world. Yet, ever since, despite enormous advances, science has resisted the precept implicit in the quantum mechanical formalism now increasingly confirmed by the experimental evidence, that reality is fundamentally non-local and reducible only locally to the classical Newtonian understanding that subsumed science before Planck's discovery. Even now such advanced ideas for the unification of physics such as string theory begin by quantizing an essentially classical model. Yet the expanding science and emerging technology of quantum cybernetics and information processing will, I am now convinced, change this. In particular, quantum holography/holochory offers such quantum non-local modelling such as quantum neural information processing or the completion began by Einstein, for Riemann's programme for the geometrization of physics, where the local classical models emerge as invariants. It is not therefore that neural networking or Einstein's general relativity are wrong, but that they are of limited application to modelling the reality in which we live, and that quantum models offer a new category of explanatory power, as this paper attempts to demonstrate, the breadth of which has yet to be fully appreciated.

Keywords: hypercomputation, category theory, quantum neural processing, holography, intelligence

1 Introduction.

Cybernetics, the study of control and communication in man and machine, has always recognized that brains have some operations that are astounding from the engineering, technical viewpoint. Indeed, these are what cybernetics seeks to explain. For while digital computers simply manipulate bits so as to perform man-designed tasks, often in rapid and very sophisticated ways, it is, I have always been convinced, an abuse of language to claim that they can, like biological brains, be autonomous, intelligent, cognitive systems, able to process information so as to taxonomize knowledge, communicate, anticipate and

understand meaning. For is not, the digital computer -a logic device- subject to the limitations of the Entscheidungsproblem and instrumental in Turing's confirmation of the Godel proof? (Turing, 1936)

2 Why Therefore am I Equally Convinced that Biological Brains are Hypercomputers.

One reason is that despite many years of research, computer science in general, is as yet unable to mathematically define the nature of information, knowledge, meaning, let alone intelligence! Yet, without this understanding, can we truly know how to process information? Processing, for example, requires that the information processed be canonically labelled, and consistently categorized if, as Godel showed, paradox, error and omission are not to occur. This, category theory now tells us, requires an enhanced Heyting instruction set/geometric logic (Heather,Rossiter, 1994)

Another, is that various theories of extended Turing computation already exist, such as, anticipatory computation, incursivity, hyperincursivity, (Dubois, 1999) and fractal intelligence (Dubois, 1992), the main subject of this conference, and, for example, others (Blum et al., 1997) based on various generalizations of number, such on Conway's surreal number (Clement et al., 1993), which enables these extended theories themselves, to be categorized.

My primary reason is, however, evolution and the laws of physics. Evolution is the modus operandi for the development of living systems, and in particular, the human brain. These systems are all chemically based information processing designs, and, as Feynman points out without quantum mechanics, there can be no chemistry, and nor, therefore, any of the other levels of chemically designed complexity such as living systems. Yet, recent research into quantum information processing shows, (Various Authors, 1998) quantum dense coding of information exists, whereby twice as much information can be transferred as is possible in the corresponding digital mode, and (Rice, 1992; Schleich, 1999) that such quantum processes include the optimal control of chemical systems by means of quantum selective bond chemistry. Would it not be truly remarkable therefore if biological systems, and brains, had failed to utilize such naturally available physical design principles and mechanisms (now demonstrable in the laboratory), since these convey substantial evolutionary advantage? That is to say, the premise held by many scientists that living systems and brains have an information processing dynamics and morphology confined to classical physical mechanism, equivalent logically to digital computation, is almost certainly false. Equally it provides cogent reasons why computer science has lacked the ability to mathematically define the nature of information, knowledge, or intelligence. For a physical theory, the quantum theory of computation (Deutsch, 1985) with an enhanced instruction set, now replaces the mathematical/Turing theory as the

correct one, and it must be hypothesized that information, knowledge, and intelligence, etc are physical concepts and processes. Further in a physical theory it becomes literally true that the human brain is the living proof of intelligence, since the only valid proofs are now physical apparatus, which demonstrate the process in question. It can therefore be postulated that the search to understand hypercomputation beyond Turing computation as conceived by Turing (Copeland,Proundfoot, 1999), is the search for a model/theory, which will explain the information processing morphology and dynamics of the human brain. And if the principles leading to a satisfactory explanation are forthcoming, a better mathematical and physical understanding of the nature of information, the categorization of knowledge, and intelligence ought to follow.

3 Some Evidence for such a Postulate:-

A. Neural nets, a highly successful discipline, based on the concept pioneered by Hebb, of the biological synapse/neuron as a weighting function, has advanced the computational understanding of the learning process. A discipline, which can be generalized to quantum neural processing, in the same way that quantum qubit processing generalizes bit/Turing processing, if now weighting is defined as the quantum superposition of all weighting possibilities simultaneously, implying C^{∞}dimensions of possibility rather than 2^N as for qubit quantum parallellism (Various Authors, 1998)

B. Take, for example, the essential complementarity of quantum physics, which is an anathema to many philosophers. Yet if quantum theory is to yield a consistent categorization of physical phenomena, and via the renormalization group it does (Wilson, 1983), by predicting the stable and unstable critical points ie the phase transitions of all matter, then there must be both categorial objects (ie particles/quantum systems) and morphisms (ie waves/fields), so as to allow description in terms of functors and natural transformations. Thus the usual Dirac formalism, while correct, may well be inadequate to provide a full description of the quantum physical world, in the way category theory (in terms of objects and morphisms) potentially can (Fatmi et al., 1990).

C. Similarly, the prejudice in favour of classical physics, surely, stems from its ability to adequately describe some of the physical world as we now visualize and understand it. A visualization and understanding, it is often said quantum mechanics cannot provide. This is erroneous, for quantum holography (Schempp, 1992; Marcer, 1995), which concerns phase conjugation, the condition such that object image and object coincide, is able to do just that!
It describes the quantum physical principles, which allow the 3D images of real objects (including, of course, the 3D geometric information about the object(s)

with respect to some relativistic observer) in the context of wave illumination of whatever type, to be encoded to, and decoded from, quantum superpositions. Thus what is observed/sensed (to some degree of resolution, depending on the sensory apparatus) is the actual wavepacket of the object with respect to the illumination, and these object images are described/located phase conjugately, where the objects actually are. This last condition is not only essential to survival in living systems, but one, where the objects of the physical world themselves implicitly provide an iconic canonical labelling for the imagery, since each object is uniquely located in 3D space. Thus, in this model (Marcer,Schempp, 1998) in contrast to digital processing, the quantum physical information encoded /decoded concerns :

a) a consistent categorization/labelling of the 3D reality we all experience, potentially suitable as a basis for communication/language,

b) knowledge about the actual physical 3D world, specifying meaning and the quantum holographic (potentially cognitive) processing of meaning,

c) information, not as bits, but as actual physical wave interference patterns. These can be hierarchically written (ie encoded) and read (decoded) in massively parallel mode, so constituting an associative holographic filter bank and memory. Here input proceeds top down (ie from whole images to partial imagery) and recall is bottom up, so that the assembly of a whole from its parts is guaranteed and the binding problem solved,

d) processing by phase conjugate adaptive resonance. This is analogue by means of adaption/learning (rather than algorithms). It is able to deal with exponential or even exponential towers of complexity diffeomorphically.

4 Intelligence, the Key to Everything?

Quantum holography, also allows intelligence to be categorically defined in a way that can be illustrated by three metaphors, the jigsaw, the elephant and the lighthouse (Marcer, 1998), as follows :

1) Unique perspectives, with respect to the observed from the viewpoint of an observer, together make up a whole picture. These perspectives are, therefore, the pieces of the jigsaw.

2) Such observers may be compared to the three blind philosophers taken to feel an elephant, who respectively describe the tail, a leg, and a tusk; leading each to an observation apparently at odds with the others, but which, in fact, is a consistent aspect of the whole, an elephant.

3) Consider an observer walking on the seashore on a dark night with thick, low cloud, who sees only a faint light reflected from the surface of the waves. Such an interference of light with water waves is a hologram; an encoding, which could be decoded, if one could control the source of the water waves, so the surface of the sea becomes flat. That is, like a mirror as on a calm night, in

which one sees the image of the source of the light waves -a lighthouse- in this case! This metaphor is almost an exact analogy for the encoding and subsequent decoding of a hologram, and for the encryption/decryption of an image or a message/meaning, where the original wave interference is, in fact, an exponential map or 'disordering', and so is seen as random ; although, in fact, it is not !!
Thus intelligence (Marcer, 1997; Fatmi,Young, 1970), the perception of order, where none was previously perceived within such a 'disordering' or exponential map, is the discovery of the inverse logarithmic map, which the diffeomorphic Lie formulation of quantum holography shows, exists, and provides a methodology to find. It says, for example, in such a model quantum cosmology (Dubois,Marcer, 1992), that the mathematical message being intelligently sought by science, ie a Theory of Everything, exists, can be identified with the lighthouse or source of a unified illumination or field, and that evolution, adaption and learning are all aspects of the same fundamental core process, which is phase conjugate adaptive resonance. It is indicative of an autonomous self organization, from which intelligence, as defined here, would emerge as the problem solving capacity of the human brain. Thus, if quantum holography is able to describe the principles governing the information processing morphology and dynamics of the human brain, as its predictions as a physical theory (Marcer,Schempp, 1998; 1997) indicates it may, then these principles could indeed also be the basis of the Theory of Everything.

4.1 Further Evidence in Favour of such a Model Cosmology.

The model, as theoretical physics, predicts that the 4D invariant pathcurves of such 3D objects concern 4D geodesics, which are those predicted by general relativity, and the 5D invariant pathcurves are 5D geodesics, ie those of the Klein-Kaluza equation, which concern both general relativity and electromagnetism! .....

5 A Discussion on the Nature of Holography

Question: In what form, does information/knowledge directly exist in nature? That is, as distinct from the bit or the qubit which are physically realizable mental models for the carriage of symbolic information, but where the nature (ie type) of information (if any) remains to be defined.

Answer: As object illumination, which the experimental processes of holography demonstrates is sufficient to facilitate full 3 dimensional wavefront reconstruction of the object image bearing illumination to some degree of resolution.
This reconstruction, known as a holographic decoding, modelled with respect to

both amplitude and phase, shows that 3 dimensional geometric information (with respect to the object imagery) is encoded in the hologram (see below) from which the decoding takes place.

Question: How is data capture possible so as to include both amplitude and phase information necessary to full 3 dimensional wavefront reconstruction of object image bearing illumination ?

Answer: By holography using wavelet mixing with non object image bearing illumination, so as to form an interference pattern/encoding of the object image bearing illumination known as a hologram. Such holograms, not only act as a record of the object image bearing illumination itself, ie of 3 dimensional objects in the context of their illumination, but may act as filters by means of which subsequent holographic input ie holograms maybe compared. Quantum holography describes such filtering, as providing an associative self-organizing paged memory and filter bank with no cross talk between the pages, from which holographic information can be written/encoded, read/decoded. This holochory ie holography, holophony, etc is such that the context of the illumination defines the object (image) qualia, with respect to the source of the non object image bearing reference illumination ; this source being, for example, the sensory receptor of the observing apparatus. The nature of these qualia therefore depends on i) the nature of the illumination, ie electromagnetic in the visible spectrum ie visual; acoustic; tactile; etc and ii) the filter bank history of the observing apparatus ie its "experience". That is, the object image bearing illumination and the non object image bearing (reference) illumination are in holochory, fundamental aspects of the observable and the act of observing by an observer, respectively. The quantum process descriptions of holochory or mental model can thus be taken to implicitly include the act of observation on the part of an observer even before these exist. So a quantum holographic universe would be self observing in this sense, and it can be postulated, can give rise to such acts by means of actual observers. For example, in the quantum brain/mind, mental events and processes can give rise to neural physical events and processes, and vice versa. That is to say, these mental and neural events and processes, can be thought of as the virtual and real parts respectively of a complex quantity describing the complete mind/brain state or process, which determines the observable behaviour of the whole organism.

Question: In what form do such records/holograms information exist?

Answer: As analogue interference patterns of energy having both amplitude and phase information. Thus full wavefront reconstruction maximizes the physically available knowledge of the real world (with respect to the reference

illumination) for both recording and decision processes at any stage of quantum holographic information processing in a way no other form of information processsing can. In particular, digital data capture and processing neglects phase information, unless models are invoked to reconstruct it, and so at best provides an approximate picture of the 3 dimensional observable real world.

Phase information, full wavefront reconstruction, and quantum holography therefore offer via natural selection such evolutionary advantage, that it seems certain that they must form an essential feature of biological mechanisms and organisms. Especially since at the chemical level, quantum phase and quantum state holography describe optimal control of chemical reactivity as performed in the laboratory. Such control is a prominent feature of reactivity in organisms, for example, the Krebs cycle. If therefore, as now seems likely, phase, and full wavefront reconstruction are fundamental elements of human perception, then, for example, sight is not fundamentally a stereographic mechanism, but a quantum holographic one employing phase conjugate adaptive resonance (where signal amplification is observed when object image and object coincide). Here the stereographic aspect of the eyes provides attention ie an anticipatory visual 3 dimensional 'grasp' of objects or aspects of objects within the visual frame/perceptual window. What Steckner (1998) defines as anticipatorial maps providing the visually percepted representations of true 3D objects to prepare the path for intentional goaldirected movement. A window the brain/eye quantum holographically reconstructs as a 3 dimensional whole, before its imagery is filtered/decomposed into its parts, according to individual's perceptual and cognitive history of experience, so as to reinforce both positively and negatively that history, alerting the mind to the object sought or from it to a higher priority.
This seems to be born out by a) the efficiency of perception and cognition, which holography/ full wavefront reconstruction would offer over stereographic reconstruction as explained above, and b) the fact that many people, but not all, are able to reconstruct a 3 dimensional image from two appropriately presented stereographic ones, ie their brains generate the phase information necessary for the full wave front reconstruction of the three dimensional image. Full 3 dimensional wavefront reconstruction of object images by means of quantum holography as the basis for perception and cognition, implies that what is perceived and cognized is the object wavepacket with respect to the object image bearing illumination, be this visual/acoustic etc. Further since all objects occupy a unique position in 3 dimensional space at any one time, such reconstructed object images implicitly provide the canonical labelling necessary as the fundamental basis for any form of communication/computation/language, ie by means of objects names or coordinates.

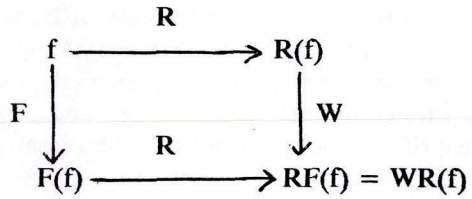
6 Some more Mathematical Background.

6.1 The Fundamental Spectral Theorem.

1. The commutative diagram (A) expresses the syllogistic representation of the fundamental spectral theorem of Hilbert and Von Neumann, setting out the relationships/morphisms in the Hilbert space, between the vectors f, their corresponding self-adjoint operators F, measure functions W and rotations R.

Diagram A

THE FUNDAMENTAL SPECTRAL THEOREM
OF HILBERT and VON NEUMANN



The Lie and therefore implicitly topological group presentation of the diagram shows that :

a) for each R(f), an inverse rotation R^{-1} exists such that $F=R^{-1}WR$, ie that a diagonalization is possible for every F(f). Thus, this syllogism constitutes a model of observation/measurement and, indeed, quantum computation, since the vectors f can be put into orthogonal form as a quantum linear superposition and constitute a mapping onto the integers,

b) in Lie transformational theory, the natural Lie diffeomorphism or differentiable mapping (morphism) with a differentiable inverse, is the exponential map (exp:) and so its inverse the logarithmic map (log:) exists,

c) it can been shown (Bowden, 1996; Manthey, 1996) that the linked chains of relationships between the corresponding homologies and cohomologies, as set out in diagram (B), exists in quantum mechanics.

Diagram B (with acknowledgement to Keith Bowden.)

$$
\begin{array}{ccccccccccc}
 & & \partial & & \partial & & \partial & & \partial & & \\
\ldots\ldots & 4 & \rightarrow & 3 & \rightarrow & 2 & \rightarrow & 1 & \rightarrow & 0 & \text{(dimension)} \\
 & \text{op}\downarrow\uparrow & & \text{op}\downarrow\uparrow & & \text{op}\downarrow\uparrow & & \text{op}\downarrow\uparrow & & \text{op}\downarrow\uparrow & \\
\ldots\ldots & 4 & \leftarrow & 3 & \leftarrow & 2 & \leftarrow & 1 & \leftarrow & 0 & \text{(dimension)} \\
 & & \delta & & \delta & & \delta & & \delta & &
\end{array}
$$

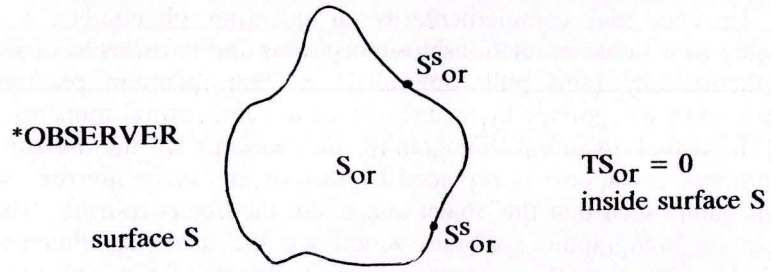
The operators ∂ and δ are seen, in the Lie context (A), as generalised differential and integral operators, respectively, where for every appropriate homology, there is a corresponding cohomology with substantial structure in between,and

d) this relational presentation in terms of the field of vectors f, would also imply by category theory, that there exists a dual interpretation in terms of objects. Diagram (C) is such an interpretation -the relational syllogism of Huygens' principle of secondary sources for the generalised propagation of a wave- discovered by Jessel and Resconi (1986), where the objects are the sources of the field.

Diagram C

$$\begin{array}{ccc} & \xrightarrow{OP} & \\ F = F(0) & & S_{or} = OPF(0) \\ \downarrow T & & \downarrow \\ F(t) = TF(0) & \xrightarrow{OP} & S^s_{or} = (OPT\text{-}TOP)F(0) \\ & & = (OP,T)F(0) \end{array}$$

Example.



(C) expresses a field F in terms of its source S_{or} through the operator OP, such that $S_{or} = OPF(0)$ and $F(0) = OP^{-1}S_{or}$ so that OP^{-1} exists, and relates the propagation of the field F(t) at time t to the formation of secondary sources S^s_{or} on a surface S, via an operator T. Such that, for example, TS_{or} is zero inside S, and in this case, therefore, from the point of view of an observer outside S, it is possible to substitute the source S_{or} by secondary sources S^s_{or} on S. Thus T is a Heaviside operator, equivalent to the singular Green's function (Schwartz distribution) that permits the corresponding description of the same phenomenon by means an integral formula. For example; T in three dimensions, corresponds to the Dirac delta function ; Feynman's sum of

histories approach is such an integral formulation of quantum mechanics grounded on Huygens' principle; and in the lighthouse metaphor, T represents the means to describe the calming of the sea within a boundary S, or in terms of its Heaviside dual, to restore its wave motion, ie to describe the performance of the necessary holographic decoding and encoding respectively, of the image of the lighthouse, which is the source of the illumination. The operation therefore that is essential to the definition of intelligence given in the main text. It indicates how by analogy with the lighthouse, it would be possible (in principle in a model of the brain working quantum holographically) to control the source of waves so that the brain would be intelligent and quantum computer constructor universal.

Dubois (1998) has also established a connection between Huygen's Principle, incursion, hyperincursion, and his model of fractal intelligence based on the Fractal Machine.

Note that:

i) The dual diagrams (A) and (C), where three dimensional space and time are implicit and explicit respectively, are seen to correspond within the standard quantum formalism to Heisenberg and Schrodinger (wave) formulations respectively, revealing what the standard formalism conceals ie the relationships of diagram (B); namely the hierarchical twin 'anti-parallel' chaining structure and the twisted isomorphisms that link them together.

ii) The essential complementarity of quantum phenomena ie wave/particle duality with fields as relationships/morphisms and particles as objects is essential mathematically (and philosophically!) so that quantum phenomena can be consistently categorised by means of functors and natural transformations !

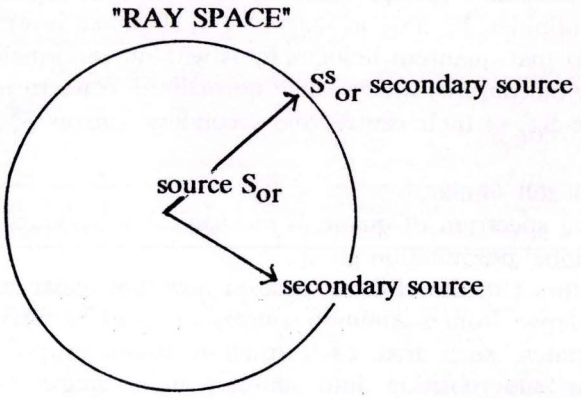
iii) In actual quantum holography, the concept of the mirror cited in the lighthouse metaphor, is replaced by that of an "active mirror" working phase conjugately such that the object image and the object coincide. That is, a model quantum holographic eye/brain would see the incoming illumination from an object as outgoing illumination coincident with the 3D object in every geometric particular with respect to the nature of that illumination. Thus, in this case, sight would be, as reality would be, a quantum holographic linear superposition; phase locked at some level of scale (ie the visible spectrum) to that reality. A testable hypothesis, is that not only does quantum mechanics map onto reality, it is reality. Try out this hypothesis; just look out of your eyes and see the superposition for yourself !?

6.2 Ray Space.

An interpretation of diagram (A) is that it provides a unique global mathematical perspective from which to view all the other perspectives F(f) (defined on the quantum mechanical ray space of vectors f, figure (D)), as self

similar and as constituting a signal/measure space in accordance with the measure functions WR(f). These perspectives (exemplified in the metaphor of jigsaw and elephant) are implicitly geometric, because of their implicit mathematical Lie presentation in the commutative diagram (A). Such an implicit geometric presentation can be made explicit, by introducing the three dimensional representation of the nilpotent Heisenberg Lie group, the Lie algebra of which is an expression of the Heisenberg uncertainty principle as was known to Hermann Weyl in 1928; the Heisenberg group is the basis of Schempp's formulation of quantum holography.
These perspectives -signals in the ray signal space (D)- therefore determine a Lie group invariance, appropriate to the observed from the perspective of an observer. This can therefore be hypothesized as Lorentz invariance, which is known to hold universally in quantum mechanics with respect to the transmission of signals.

Figure D



The mathematical description of diagram (A) applied to figure (D), thus constitutes a universal relativistic quantum holographic model of the theory -quantum mechanics- defined on the ray signal space; a computational model, which is a universal model of the quantum measurement process and is quantum computer constuctor universal , since it :
a) applies for all vectors f in the Hilbert space
b) is Lorentz invariant
c) concerns the perspectives F(f), which are known from Schempp's work to have an explicit geometric presentation through the Heisenberg nilpotent Lie group in terms of three parameters x,y,z which are spatial measures. But a prototypical holographic machine for the control of quantum measurement as

described by Schempp (1998), the (nuclear) magnetic tomographic resonance imaging machine already exists ! It has an interface to existing digital computer technology by means of which input and output from its quantum co-processor, are performed for the purposes of specifying the desired brain/body slice images required and their display, respectively ! At this interface, the output, a holographic diffraction pattern (hologram) obtained by spin echo techniques, is converted into the required image by fast Fourier transform techniques using the digital processor.

6.3 Quantum Holography as Quantum Measurement Embraces the Whole of Quantum Theory.

From the ray signal space (D), it can be seen that the rotations R, diagram(A), can be used to define field automorphisms, which map the ray space onto itself, so the rays/signals of the space are under permutation ie concern the infinite dimensional permutation group, which is, of course, an exponential map. This introduces no infinities, because as diagram (A) shows an inverse transformation always exists, so that quantum holography is without renormalization problems. Thus these automorphisms, which, when normalised, concern unit rays having a common source S_{or} at their centre, and secondary sources S^{s}_{or} at the unit ray ends :

1) are clearly all self-similar,

2) cover the full spectrum of quantum mechanical behaviours by means of the infinite dimensional permutation group,

3) concern vectors f in the Hilbert space in quantum linear superposition, and signals, which derive from a common source, and thus correspond to entangled or squeezed states, such that each rotation R/automorphism converts one quantum linear superposition into another in a single step - a process exemplifying massive quantum parallelism,

4) moreover in the case of unit rays/signals ie normalization, the Lie diffeomorphism concerns exp: 0 = 1, and the inverse mapping log: 1 = 0. Thus, the automorphisms constitute a universal model of a theory in the language of sets $Z_2 = \{0,1\}$ and hence theorems of Erhlich (1989, 1986) tell us, there exists a unique birthordering of these automorphisms. This can therefore be postulated as specifying the incremental evolution over time of this quantum universe (of discourse), where the initial signal automorphism of the discourse describes a initial resonance, eureka event or act of creativity.

These make good sense in relation to quantum holography, a creation/ annihilation model :

i) as prior to each incremental massively parallel step n of the evolution by means of a rotation R_n $n=1,2,3,.. \infty$, there will be the temporal and the spatial coherence necessary for holography, and S_{or} will correspond to a squeezed

signal state,
ii) at each massively parallel annihilation, the holographic source S_{or} encodes all of holographic information appropriate to the evolution/learning process so far.
iii) at each creation, S_{or} will be erased and substituted by its set of secondary sources S^{s}_{or}, which, diagram (C) shows, perfectly simulate it (ie it is quantum computational in the Deutsch (1985) sense),
iv) such simulations, by means of which the process proceeds, involve automorphic mappings, and so are phase conjugate adaptive resonances (ie holographic decoding /encodings), and
v) at each annihilation, the secondary sources S^{s}_{or} reconstitute their source S_{or}, incorporating the change happening in the previous incremental step. This corresponds to the measurements/observations which took place with respect to time and space in that increment, ie the change of signal energies of those secondary sources.

7. Conclusion

That a quantum universe, as all that exists, is such that as a whole, it maps itself onto itself ie automorphically, adaptively changing itself at each evolutionary step. This is a self-organization, where under the appropriate conditions, life, DNA (Marcer,Schempp, 1996; Clement et al., 1993), living cells/units (ie observers of their environment (the observed)) (Marcer,Schempp, 1998/1; Marcer, 1997/1), nervous systems (Marcer,Schempp, 1997), brains, consciousness, language communication, formal systems, (Marcer,Schempp, 1998), intelligence (Marcer, 1997), mathematics (Chapline, 1999), etc, are all inevitable emergent consequences of physical law, and where, the listed adjacent references represent part of an on-going research programme to substantiate or invalidate this thesis. A next step in this programme, is seen as a prediction of the experimentally observed microtubule structure, by means a description of the theoretical physics of quantum holography of microtubular morphology and dynamics. A testable prediction such that if the description matches that observed structure, quantum holography is a good model, and if not, it is an incorrect model.

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