THE MODEL OF THE PROKARYOTE CELL AS AN ANTIPATORY SYSTEM WORKING BY QUANTUM HOLOGRAPHY

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ABSTRACT
Testable theoretical predictions in the form of mathematically specified templates for morphology and dynamics can be made using quantum holography. This has already been shown to be the case for DNA and will be shown to be the case for the simplest cells - the Prokaryote.
Keywords;-Models,DNA,Prokaryote cell,Quantum holography.

INTRODUCTION
Quantum holography supplements the learned soundscreen of language and diagrammatic morphology that currently give molecular biology its explanatory power, with a potential mathematical explanation. In the case of DNA, this explains how the 3 dimension morphology and dynamics of DNA enable it to encode the 3 dimension morphology and dynamics of the embryo of organism[Marcer,Schempp,1996].
It thus explains why the structure of actual DNA is the way it is. It says that DNA is a quantum linear superposition in chemically encoded form for the orthogonality or sharp frequency adaptive coupling conditions pertinent to organism's behaviour.Thus when incrementally decoded, DNA yields the 3 dimensional morphology of the embryo of its organism as the basis for the organism's autonomous behaviour including the ability to adapt and learn. DNA therefore provides the mathematical explanation says, an internal model of its organism's dynamics, and by implication of its organism's environmental niche determined by evolution, capable of computing the current state of the organism as a function of the prediction of its model or DNA. What Dubois[1997] has defined as an anticipatory model.
The case of the simplest cell or prokaryote is chosen to test this mathematical explanation of morphology and dynamics,and in particular of DNA already made . Can quantum holography also predict why the actual structure of prokaryote cells are the way they are? The answer is yes!

THE NATURE OF THE MATHEMATICAL EXPLANATION.
This is quantum mechanical[Schempp,1992,1993]. Let $\psi(t)$ and $\phi(t)$ be the wavefunctions describing the cell and its environmental niche respectively. The simplest anticipatory model says that

$$\psi(t)dt = c\phi(t)dt \quad \text{where } c \epsilon T \qquad (1)$$

is a constant phase factor and T is the compact torus group. The free choice of the phase factor $c \epsilon T$ reflects the fact that only the phase difference is of physical significance in quantum holography and that the holographic image encoding

procedure which applies to any kind of physical wave needs the mixing of a coherent or partially coherent reference signal beam to interferometrically record the phase of the object signal beam in the hologram plane.
Thus (1) implies in quantum holography that

$$H(\psi; x,y)dx_{\wedge}dy = H(\phi; x,y)dx_{\wedge}dy \qquad (2)$$

where H(; x,y) is the holographic trace transform which describes quantum self-interference and (x,y) belong to the hologram plane $R\oplus R$ where the interference takes place. The prokaryote cells are therefore self-organised cells working the model says by phase conjugate adaptive resonance such that the object image of the cell - its dynamics - coincides in each time frame with the cell itself, i.e. its morphology .

Hence $\psi(t)dt \rightarrow H(\psi; x,y)dx_{\wedge}dy = H(\phi; x,y)dx_{\wedge}dy$
maps onto

so extending the mapping of the Hilbert space $L^2(R)$ onto $L^2(R\oplus R)$ and confirming Maturana and Varelas' postulate that a living system is an operational closure, which(it is shown below)distributes matter between inside and outside but autonomously decides what kind of matter permeates the hologram plane or cell membrane.

It follows from the mathematical description of the Heisenberg Lie Group G, the symmetries of which determine the quantum coherence and phase conjugation necessary for holograhy[Schempp,1992],that a) in the case of (1) and (2) therefore ,these symmetries project onto the compact Heisenberg group nilmanifold which forms a principal circle bundle over the two dimensional flat torus T^2, and
b) that there must exist point orbits $O(\eta,\mu)$, where $(\eta,\mu)\epsilon R\oplus R$ the hologram plane, associated with the dual vector space of the Lie algebra $g = T_{(0,0,0)}(G)$ of G which is formed by the upper triangular matrices $\{(x,y,z)\text{-}(0,0,0)\,|\,x,y,z\epsilon R\}$.
Thus since these orbits correspond to sources and sinks, they must be those which distribute matter in the form of chemical molecules/signals between the interior and the exterior of the cell passing them through the cell membrane or hologram plane. In fact these orbits, the mathematical explanation shows constitute a set of chemical lasers(controlled by the DNA of the cell) able to optimally control the chemical reactions within the cell,in response to the changes in its environmental niche,thus enabling the cell to adapt,learn and survive. An explanation already demonstrated in the laboratory with reference to chemical soups so as to in effect solve the Schrodinger equation in real time for the chemistry of the soup, or in this case for the cell $\psi(t)dt$ [Rice,1992].
The full mathematical explanation as set out in the paper is therefore able to make the following identifications,see Figure I,
a) In these simplest of cells, the prokaryote, the DNA is the active component which changes the phase of the cell incremently so that

$$c^{-1}\psi(t)dt = \phi(t)dt$$

thus matching the behaviour of the cell to its environment in each time frame dt. The

DNA therefore constitutes the Berry phase of the cell, able to regulate its behaviour in accordance with the history of the cell. The Berry or geometric phase[Anandan,1992] constitutes a record of the quantum states which its system has passed through; where the system has been in space ;and of how long in time it was in any particular state. The above mathematical explanation says that the active DNA in these cells therefore takes a circular form,attached at one unique point (0,0,0) to the membrane of the cell which in fact is actually the case, and the action of which constitutes couple circle maps specified by the compact torus group T and the two dimensional flat torus T^2. The latter constitutes a good topological description of actual DNA where the base pairings lie in flat planes,see Figure II,when it takes this circular form in the cell.

b) But such coupled circle maps able to exhibit chaotic oscillations are a tool to model synchronization in neural networks such that

I. each map represents the phase dynamics of a group of neurons,

II. depending on the coupling strength, the different maps show correlated or uncorrelated behaviour while the autocorrelation functiom remains flat as expected for a chaotic signal,and

III. the sychronized behaviour in (II) can be organized by a simple Hebbian type learning rule.

These features show therefore that the DNA of the simplest cells constitute a "neural network" for the cell, able to adapt and to incorporate through the mechanism of the Berry phase [Anandan,1992] the cell's experience necessary for its survival. Further it shows that the DNA also constitutes a mechanism for synchronization between various components of the cell,which can be brought into play simply by changing the coupling strength between the maps,as represented in the various base pairs. In the paper on DNA it was shown that it is just these base-pairs which are able to accomodate weightings in respect of the cell's component behaviours as accumulated by the cell's experience. Such base-pairs were also shown to correspond to just two distinct categories of behaviour in terms of metrics $dx \otimes dy \otimes dz$ and those for emissions and absorptions. It therefore must be the case in the simplest cells, that the metrics $dx \otimes dy \otimes dz$ determine the incremental motion of the cell's envelope/body,while the emissions and the absorptions control in various ways the behaviour of the point orbits $O(\eta,\mu)$ or sources and sinks which lie on the cell membrane. A control which can be organised synchronously in the case of the simplest cells across various sets of sources/sinks $O(\eta_i,\mu_j)$ i= a to b and j= c to d, because the cell's DNA determines both its morphology and its dynamics, and these in the simplest cells are isomorphic.

HOW THESE POSTULATES ARE ARRIVED AT.

From the mathematical description of the Heisenberg group G[Schempp,1986,1997],the symmetries of which specify the quantum coherence and phase conjugation necessary for the holography, it follows[Schempp,1992] that in relation to $(\eta,\mu) \epsilon R \oplus R$, the hologram plane , there exists a point orbit $O(\eta,\mu)$ that can be identified with Dirac measure $\varepsilon_{(\eta,\mu)}$ if (η,μ) is located in the singular plane frequency v=0 . In this case the one-dimensional polarized unitary linear representations of the Heisenberg group apply and are given by

$$U_{(\eta,\mu)}(x,y,z,)\psi(t) = \exp(2\pi i(\eta x + \mu y))\psi(t) \qquad t \epsilon R$$

These representations of G are of the linear Fraunhofer type. They are irreducible and admit the one-point coadjoint orbits $\{O(\eta,\mu) = \varepsilon_{(\eta,\mu)} |\ (\eta,\mu)\epsilon R\oplus R\}$ - already referred to earlier - in the singular plane v=0 spanned by (P*,Q*) in $g^* = T^*_{(0,0,0)}(G)$ where g is the Lie algebra of G and which form the set of Plancheral measure zero.

This Plancheral measure π_G of G is uniquely determined by the Haar measure $dx\otimes dy\otimes dz$ and is concentrated on R -{0}. It is given by

$$\pi_G = |v|dv$$

Furthermore G can be projected onto its compact nilmanifold which forms a principal circle bundle over the two-dimensional flat torus T^2 postulated here as an essential aspect of the description of the quantum holographic model of DNA.

Thus the Haar measure/metric $dx\otimes dy\otimes dz$ implies in relation to the holographic model of DNA [Marcer,Schempp,1996] that it will allow the instantiation of a cell membrane $L^2(R\oplus R)$ together with with entropic holes which concern the emitter/absorber model of quantum holography which admits the additional Haar measures/metrics $da\otimes db/a$ and $da\otimes db/a^2$. These concern the non-unimodular affine Lie group of the real line R or (at + b)group. Thus at each hole and across the membrane ,there will be an entropic dynamic equilibrium in terms of entropy production concerning chemical molecular emissions and adsorptions, so that the entropic gain on one side of the membrane and the loss on the other side are equal and vice versa.

Thus in microcosm, the chemistry taking place in the interior of the cell is an exact analogy of the laboratory experiment[Judson,Rabitz,1992] where the chemistry carried out, corrresponds to the optimal control of an uncertain quantum system. These experiments are such that under computer control of a genetic algorithm(in the cell's case it's actual DNA/genetic code where the DNA - as explained performs its own computations) a continuous laser is " taught" to optimally control the chemical outputs from a chemical soup. However in the cell,the required spectral signatures resulting from such an guided evolution/learning of the cell,are supplied in the form not of an optimized laser spectrum but in terms of the signatures of chemical molecules admitted coherently to the cell via the entropic holes.

That is,it is postulated that the cell's DNA is able to function quantum mechanically both computationally and constructively(ie able to construct a replica of itself as a Von Neumann automaton) so that

a) the prokaryote cell computes incrementally as describes via the shift register action on the Heisenberg group nilmanifold ie topologically, concomitant with the possibilities encoded in its DNA. These possilibilities concern the base-pairings[Marcer,Schempp,1996] which contain the weighted geometric encodings with respect to the metrics $dx\otimes dy\otimes dz$ and $da\otimes db/a;da\otimes db/a^2$. that is those able to realize behaviours with respect to movement of the cell and emissions/absorptions across its surface,

b) It is to be noted that the compact ball C^2 provides a topological model of the cell itself and this can be identified with the one-point compactification of $G,\varepsilon_{(0,0)}$ where the biholomorphic geometry of the unit ball -called the Heisenberg geometry- exhibits the natural Lie diffeomorphism

$$\exp: g \to G$$

This says that the signal processing of such cells(which in this case takes place chemically) in relation to their surface activity is capable of dealing with the exponential complexity present in the environment. This is because such a diffeomorphism is a differentable mapping with a differentable inverse. It confirms in relation to model of DNA working quantum holographically that DNA here identified with the compact torus T,will be specified in terms of a helix, the Heisenberg helix. But in fact DNA is on the basis of this model, a double helix with a second helix phase conjugate(ie anti-parallel)to the first,see Figure II.It will be a double Heisenberg helix therefore at $\varepsilon_{(0,0)}$ Thus the

cell will be able to function by phase conjugate adaptive resonance as prescribed by its DNA ie autonomously through chemical selection and learning provided the environment can supply the necessary chemical energy(by means of the cell's entropic holes under control of its DNA) in a form suitable to maintain the required resonances/activity of the cell.

This is confirmed by the fact [Schempp,1992] that

$$\varepsilon_{(0,0)} = \int_R Tr_{G/C} U_v d\pi_G(v)$$

and (3)

$$Tr_{G/C} = \sum_{n \geq 0} H(H_n; :)$$

where H_n constitute the Hilbert basis of the Hilbert space $L^2(R \oplus R)$ and U_v are the irreducible unitary linear Schrodinger representations of G frequency $v \neq 0$.

Thus in relation to the cell, the base-pairings of its DNA define a set of state vectors in relation to the basis H_n so that when the morphology and dynamics of the organism is coded with respect to this orthogonal set,the holographic information processing taking place will be optimally efficient. This is because the orthogonality of the elementary holograms $(H(H_m,H_n;.,.))_{m \geq 0, n \geq 0}$ in the complex Hilbert space $L^2(R \oplus R)$ implies that in the Shannon sense the mutual information of the code coeffients is zero. The irreducible unitary linear Schrodinger representation U of G above therefore specifies the wave function of the cell as defined by the equations (3).

CELL REPLICATION

It can therefore be postulated that $\varepsilon_{(0,0)}$ concerns a threshold mechanism which when it is exceeded, leads to the replication of the whole cell,and that when it is not,determines the basis on which the adaptive resonance within the cell works. This is because an emission associated with $\varepsilon_{(0,0)}$ itself concerns the compact unit ball C^2 and the whole of the properties of the cell are defined by the set of state vectors in relation to its basis H_n. That these behaviours can happen autonomously in relation to a quantum holographic model of the prokaryote cell is confirmed by Noboli[1985,1987].For when holography is performed by excitation of stationary modes ie holograms inside a wave propagating medium with reflecting boundaries(ie here the cell walls) phase conjugation occurs spontaneously and both real and virtual images of recorded information are elicited by wave diffraction.Thus the model infers,as indeed is the case,that the prokaryote cell has the primal capabilities necessary to any living organism to reproduce. Indeed it can be argued from the

above model that the more complex cells-the eukaryote-will not have this ability to reproduce unless they temporarily resume a prokaryote-like form ie lose their nucleus,as is indeed the case.

CONCLUSION

Thus the interior to such cells must on the basis of the model be operating in partially coherent modes necessary for the holograpy,and the exterior of cell beyond its hologram plane/ boundary can be considered non-coherent with respect to the holography taking place within the cell. That is, such cells work by what is called superresolution(imaging), mimicking their environment only in a certain range of its behaviours. The other behaviours therefore constitute "noise" within which the cell must work. It is worth noting therefore that noise in relation to superresolution can be benign serving only to sharpen the nature of the phase conjugation taking place. This of course would be an advantage in favour of a quantum holographic model. Another arises from the fact that the working of DNA within the cell,is described by coupled circle maps. These while modelling the synchronization by which the cell would work,can do so through chaotic oscillations/wave motions. In fact quantum holography shows[Schempp,Pribram,1994] that the various assemblies of entropic holes,will beat stroboscopically in time to carry out their genetically prescribed functions to characteristic frequencies as layed down by the cell's DNA.

The model confirms the known experimental fact that bacteria will be able to rapidly learn to block the action of antibiotics. That is,the historical record of the cell will become weighted against the intake of an antibiotic in the case where this does not kill the bacterium. That is the cell will be able to learn in the case of low doses of the antibiotic to reduce the intake of antibiotic molecules through its entropic holes or even to exclude them altogether. This rapid action cannot be explained by mutation since this must in general happen only very slowly which is not found to be the case.

Thus such prokaryote cells are not simply able to make replicas of themselves, but have already in basic form all the usual attributes found in much more complex living systems. For as the mathematical explanation shows,that within their limited reportoire of chemical signals they are able to 'intelligently recognize and select' those chemical molecules they require or must reject from their environmental niche if they are to survive. They do not need to mutate,for they can adapt and learn,perhaps accumulating experience over tens,or hundreds or even thousands of millions of years! They are worthy adversaries of mankind indeed.

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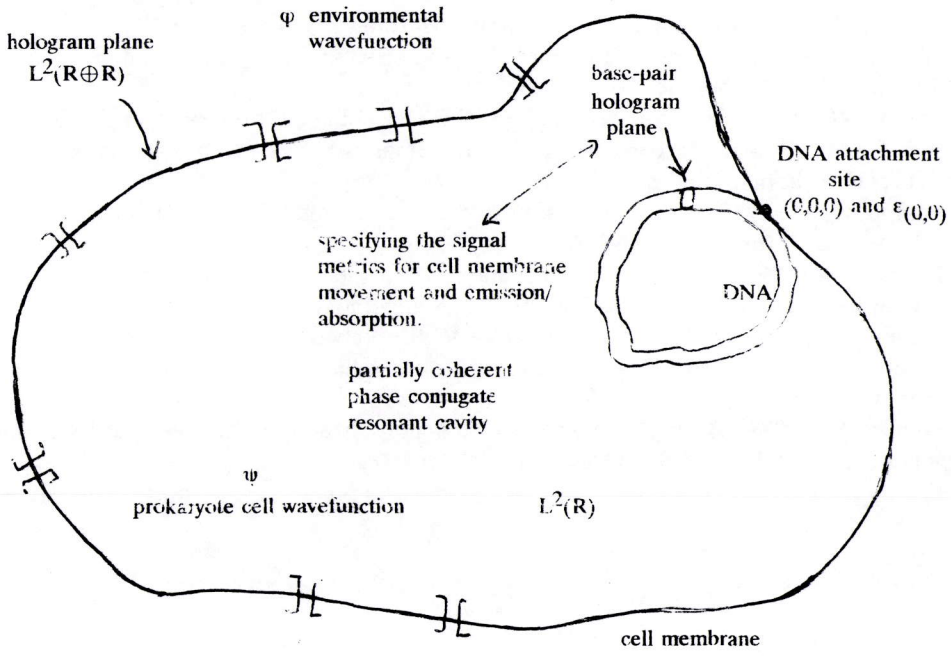
FIGURE I

SCHEMATIC OF THE PROKARYOTE CELL



] [emitter/absorber sites. These are the point orbits/sources/sinks of the holographic model which " match" chemical input/outputs to the cell's needs as its DNA requires - according to the Berry phase history of the cell with respect to its environment.

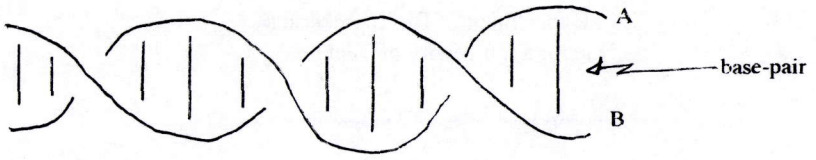
~ similarly cell membrane movement is "matched" to its environment according to its DNA requirements.

DNA The model of DNA says that it performs a wave computation of a weight history based on the cell's past both experiential and genetic. From such a wave history, as recorded in the Berry phase which the DNA instantiates, the cell "knows" what chemical molecules must be emitted and absorbed and in what proportions so as to optimize its survival in real time. DNA controls the emission/absorptions and membrane movement synchronously so that the cell acts as a coherent whole.

Since $\psi = c\varphi$ and $c\epsilon T$ the compact torus group $c=e^{i\vartheta}$,it is clear that the cell's DNA is a morphological and dynamic invariant which defines the set of phase invariances. These allow the cell in any time interval to match itself to its environment.

FIGURE II

SCHEMATIC OF DNA.



DNA - according to the quantum holographic model- is a quantum linear superposition in chemical form,where

i) the two 'backbones' or helices A and B run anti-parallel ie phase conjugate to one another,so potentiating the possibility of adaptive resonancewhen DNA is in active mode functioning as a computer as in the prokaryote cell, and

ii)the base-pairs determine hologram planes, where holographic information conceerning the morphology and dynamics of the organism is incrementally encoded appropriate to its genetic and experiential development respectively.

That is, DNA constitutes a stationary quantum interference pattern able to model the whole history of its organism as for example described by path integrals on the phase space or infinitesmal version of the Feynman path integral quantization procedure[Atiyah,1990;Resta,1997].

Thus when DNA takes a circular form attached to the cell mebrane as in actual prokaryote cells see Figure I, and its topological connectivity corresponds to that of the compact torus group T and the two dimensional flat torus T^2, it constitutes

iii) a chemical instantiation of the Berry/geometric phase[Anandan,1992] of the cell,and

iv) has the ability to perform behaviours described by coupled circle maps[Bauer M. and Martienssen,1991]