Self-reference, the Dimensionality and Scale of Quantum Mechanical Effects, Critical Phenomena, and Qualia

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Abstract
Self-reference, the postulated key to a more complete understanding of quantum mechanics, is shown to be a necessary mathematical basis for an evolution of all that exists in relation to a self-created quantum cosmology. The initial act of this self-creation - a critical phenomenon where the material phase transitions give rise simultaneously to mass and the strong, electro-magnetic, weak properties of matter in agreement with those of the standard model of elementary particle physics - is shown to concern 3+1 dimensional Lorentzian space/time and Einstein's general relativity. Similarly subsequent acts giving rise to entirely novel material phase transitions and properties of matter, as predicted by renormalization group theory for which K.G. Wilson received the Nobel Prize, may include, evidence is presented, those of self-aware, possibly conscious, living systems.
Keywords: self-referential quantum systems, geometric phase, phase conjugation, quantum holography, critical phenomena

1 Introduction

Quantum mechanical state vectors are arbitrary up to a constant phase factor. Yet, as Berry[1989] showed, the gauge invariant relative phases of a state vector constitute a new class of quantum observables, called the geometric/Berry phase, quite distinct from those, which are the eigenvalues of some quantum mechanical operator [Resta 1997]. Any interpretation consistent with the quantum formalism, which is universal i.e. capable of describing any physical behavior, quantum or classical [Deutsch 1985], is therefore a valid one in some phase domain. The large body of often heated argument over much of the last century, continuing today, as to which interpretation is to be preferred, can therefore decide nothing definitively so long as it is based strictly on the formalism alone. A boundary condition essential to the correct solution of any problem must be included, and in the case of self-reference can be defined as a mapping of the whole quantum field onto itself i.e. as a field automorphism. Such self-reference therefore necessarily encompasses the whole phase domain so as to include each and every valid interpretation in its own sub-domain, consistent with the arbitrariness of phase, and, of course, the formalism. That is to say, it constitutes a universal model of

quantum mechanics, that, as a universal model of a theory (in the language of sets), has, it is known [Erhlich 1986], a unique birthordering or birth-order field automorphism. This unique birthordering can therefore be identified with the evolution of the whole hypothesized self-referential quantum cosmology. One, such as can arise, as will be shown, from some form of degenerate physical instability, or which mathematically could arise in a Godelian manner as has been envisaged, for example, by Hofstadter [1979].

In support of this thesis of a self-referential quantum cosmology, other known self-referential quantum mechanical models are therefore examined and compared, in particular, those of :-

1) the Berry/geometric phase and its relationship to quantum chaos [Berry 1986], which, like chaos, must arise as a consequence of boundary conditions and where, in the case of chaos, self-reference can take the form of self-similar fractal systems,

2) quantum holography (QH) [Schempp 1992], where phase conjugation defines self reference such that the image of any 3 dimensional spatial object coincides with the object itself, and

3) Kenneth Wilson's renormalization group methodology [Wilson 1983] for the determination of the critical phenomenon.

These examinations show:-

1) that the postulated self-referential cosmology is in excellent agreement with the current understanding of the standard model of elementary particle physics, so as to be able to account for existence on all appropriate scales throughout the universe, of the strong, electromagnetic, weak and gravitational properties of matter as all arising spontaneously and simultaneously as a consequence of a critical phenomenon or initial unstable critical point. In particular it is shown in contradiction to the generally held view in physics that quantum theory and general relativity are incompatible, that in fact, the quantizations of mass, electromagnetic, strong, and weak charge in relation to the Rowlands/Cullerne [1999; 2001] extension of the standard model of elementary particle physics are exactly those that ensure such compatibility!!

2) that this critical phenomenon is the first resonant event in an unending incremental process of phase conjugate adaptive resonance, which, as quantum holographic measurement with reference to the cosmological reference frame produces an historical record or history enabling the postulated cosmological evolution. Thus the cosmos may be said to be self-reproducing or "cloning" itself adaptively, ie is self-organizing, and

3) citing previous research, that

a) DNA and its associate life-forms, for example, the simplest living prokaryote cells [Marcer and Schempp 1998a], can be postulated to be highly complex examples of other self-referential sub-systems, operating in accordance with the same quantum physical principles, ie by DNA-wave computation [Gariaev et al. 2001]/quantum holography [Marcer and Schempp 1996], including

b) those self-referential self-aware life-forms, such as ourselves, which maybe described as conscious [Pribram 1991; Marcer and Schempp 1997 ;1998b; Marcer and Mitchell 2001].

All provide further evidence in confirmation of the self-organising evolutionary process [Marcer and Dubois 1992] from the Self-Creation to the creation of the self [Marcer 1996].

2 The Renormalization Group Approach to Critical Phenomena

In 1982, Kenneth Wilson was awarded the Nobel Prize for his use of renormalization group methodology in relation to critical phenomena [Anderson 1982]. Experimently well validated, its mathematical basis, the repeated self-referential mapping of the quantum Hamiltonian of the particular material onto itself so to determine that material's stable and unstable critical fixed points/attractors, established a universal means for calculating material phase transitions. It is a quantum theoretic methodology which employs a rescaling/renormalization procedure P utilizing an arbitrary 3 dimensional spatial lattice [Wilson 1983], such as will be seen later, QH also employs based on the 3 parameter Heisenberg nilpotent Lie group G.

Such critical fixed points thus determine all the possible physical properties, noumena and qualia of materials. It maybe concluded therefore that, since all material properties, noumena and qualia, are a consequence of quantum mechanical effects, only in up to 3+1 dimensions as Wilson's methodology [1983] also proves, that we live in a quantum mechanical and not a classical universe. Further it follows that noumena and qualia are only subjective in the sense that they concern measurement with reference to a local measurement standard. That is to say, that in relation to measurement in any self-referential sub-frame of the universe, it is possible to establish an arbitrary measurement standard i.e. the traditional laboratory standard, for example. This is only possible, however, because in the reference frame of the universe as a whole, defined as all that exists, the quantum mechanical state vector is determined only up to a fixed arbitrary constant phase factor. But it must be remembered, in quantum mechanics, that all local measurement standards and corresponding fixed "arbitrary" constant phase factors, cannot be divorced one from the other and from those of the universe as a whole. That is to say, it is requirement of quantum mechanics that all measurements and measurement standards compose a single consistent set, and be considered as objective. For in the proposed self-referential quantum cosmology not only will entirely novel material properties result from the novel material phase transitions continually taking place as the result of repeated self-reference, but such self-referential processes will also ultimately establish the local measurement standards against which these novel material properties are measured. This argument therefore establishes a sense, self-organizational self-reference in any sub-frame, in which this hypothesized cosmology can be considered anthropomorphic, see section 5.2.

In this connection, as already cited Wilson [1983] proved, that while the corresponding classical field equations (to their quantum counterparts) can usually be applied on scales large compared to the Planck length, care is essential as this cannot always be said to be the case, as is still often assumed. That is, the earlier assumption of Landau (whose calculations were indeed contradicted by experimental findings in relation to the Ising effect) and, more recently those of Tegmark, both purportedly showing that quantum

mechanical effects only concern atomic scales, are under the circumstances to which Wilson's methodology applies, false in up to 3+1 dimensions [Wilson 1983].

Such circumstances also concern the fact that the mathematical lattice rescaling procedure P fundamental to Wilson's renormalization group methodology for the determination of material phase transitions corresponds with that used in Schempp's quantum holography (QH) [1992] described in terms of the 3 dimensional Heisenberg Lie group G. Thus, the processes of QH, which, for example, provide an experimentally validated mathematical foundation for the workings of magnetic resonance imaging (MRI) machines and synthetic aperture radars [Schempp 1998; 1986; Binz and Schempp, 2000a and b], are, in principle, a physical means to realize Wilson's lattice rescaling procedure P, so as to show :-

i) the nature, dimensionality and scale of quantum mechanical macroscopic effects in relation to the quantum holographic models to be described or cited, of an inflationary cosmology, elementary particle physics, and the living world, and

ii) that the boundary condition of self-reference can be identified :-

a) from considerations of Berry phase [Manini 2001], with a totally degenerate zero energy point,

b) from considerations of Wilson's [1983] theory of critical phenomena, with an unstable fixed point/universal attractor, and

c) with a universal saddle point determined in terms of the Golden Number [Marcer 1992],

so as to provide an explanation of the hypothesized cosmological evolution.

(a) then says that such an evolution would remarkably be one of entirely geometric-topological origin taking place in the potential landscape of the Hamiltonian parameter space [Lloyd 2001; Manini 2001] rather than being, as is usually supposed, of dynamic origin. This would explain why, as we all aware, there is quite literally "no time like the present". For now there need be no Schrodinger dynamic evolution of the wave function (see section 6), only an incremental 'process' of morphological natural selection, akin to Darwinian evolution, in that whole potential landscape. What one of us [Mitchell and Williams 1996] has called "The Way of the Explorer". Thus change takes the form of material phase transitions relative to an initial phase transition suggesting a resonant model, such that the self-referential systems and subsystems to be described, bootstrap themselves into existence as critical phenomena. It would also, as a universal model of a universal theory [Deutsch 1985], provide a 'Platonic' explanation for the undue effectiveness of mathematics in quantum physics or vice verse an explanation of the quantum physical realizability of mathematics.

The notion that self-reference in quantum mechanics, a universal theory, defines a universal model of the whole quantum field emergent from a universal saddle point/singularity, is therefore in line with Chapline's [1999] conjecture "Is theoretical physics the same thing as mathematics?". His basic argument shows that quantum mechanics, which offers a natural approach to the vector quantization needed in pattern recognition [Kohonen 1988], can, in its Wigner-Moyal formulation, indeed be interpreted as canonical holographic method for solving pattern recognition problems

(as indeed can QH! [Schempp 1992 ; Marcer and Schempp 1998b]). This leads him to conclude

i) that the pattern recognition capabilities of the human brain are responsible for " the unreasonable effectiveness of mathematics in relation to physics", and

ii) that the program for the unification of physics is intimately related to *Langlands'* program for the corresponding unification of mathematics. This program, postulating that the previously supposed independent branches of mathematics actually in fact constitute a related whole, is now nearly proven and has just been extended to include function fields [Mackenzie 2000].

Such conclusions are also in accord with Wheeler's [1986] hypothesis of "*the meaning circuit*" that while physical laws are described by "algorithmic" means, such algorithms cannot be executed without recourse to the physical processes those laws specify.

3 Phase Conjugation

Phase conjugation, where the image of an object coincides with the object itself, is an experimentally validated condition of self reference in quantum mechanics. In use, for example, as the basis of the spin echo image measurement control techniques in magnetic resonance imaging (MRI) [Schempp 1998; Binz and Schempp 2000a,b], it is the necessary condition for incremental phase conjugate adaptive resonance in QH specified in terms of the 3 dimensional Heisenberg Lie Group G [Schempp 1992]. It can therefore be postulated to define a self-referential cosmology as a quantum holographic phase conjugate adaptive resonant whole :-

i) where the whole and each of the objects or phase conjugate quantum mechanical sub-systems has a coincident quantum object image or self, and

ii) where such selves concerning observable gauge invariant phases of the quantum state vector or Berry phase, are therefore not just an epiphenomena, as spin echo measurement techniques employed in MRI demonstrate.

Such a phase conjugate cosmology (as all that exists) must therefore begin with the initial act of quantum holographic phase conjugate adaptive resonance, which takes place the cosmological reference frame. This model is therefore in excellent agreement with Wilson's renormalization group methodology determining the universal nature of material phase transitions. For this methodology also employs, as already mentioned, the repeated self-referential mappings of, in this case, a quantum Hamiltonian onto itself, so as to select the particular material's stable and unstable critical fixed points, and shows that quantum mechanical effects determining such fixed points, are significant only in up to 3+1 dimensions.

This says:-

a) that the continuum laws of classical mechanics may not apply in macroscopic spatial dimensions in the neighborhood of such critical fixed points; for example, where water exhibits material phase transitions (such as ice or steam) so that the classical equations of hydrodynamics [Wilson 1983] no longer hold. Another example of the failure of classical macroscopic continuum laws, is the radiation law, as its divergence proves. For this divergence led Planck to the discovery of his now well proven quantum radiation

law, the necessity for Planck's constant, and to the discovery of quantum mechanics itself. Furthermore, it is again evidence of a microscopic quantum mechanical effect having consequences even on the cosmological scale, and

b) that, in these circumstances, most likely quantum holographic effects do apply, since these are, in principle, a physical means to realize the lattice rescaling procedures P that Wilson's methodology employs. For example, at the unstable critical/saddle point of water/steam there is indeed a "holographic" mixture of bubbles of steam containing droplets of water and vice versa, on all scales down to the atomic.

(b) is further confirmed by the fact that quantum holography is Lorentz invariant (can be interpreted as holding in up to 3+1 dimensions consistent with Wilson's findings) and is based on the mathematics of the 3 parameter Heisenberg nilpotent Lie group G, matrix representation

$$\begin{array}{ccc} 1 & x & z \\ 0 & 1 & y \\ 0 & 0 & 1 \end{array} \qquad \text{written as (x,y,z) for convenience}$$

such that the Haar measure of G is the Lebesgue measure $dx \otimes dy \otimes dz$ of the underlying differential manifold R^3 where $\otimes$ stands for tensor multiplication, so that (x,y,z) are indeed three spatial measures.

In the postulated cosmology, such material phase transitions would not only determine all the physical properties, noumena and qualia, but it can inferred would give rise to the cosmology itself, through a unstable critical fixed point, such as a event where phase conjugate adaptive resonance takes place. Further Wolfram [1984] has shown that such critical fixed points or attractors are of four basic types, consisting of, point, periodic, strange chaotic and computer universal. Thus the cosmological models under discussion namely those concerning the Berry/geometric phase, quantum holography, and Wilson's universal methodology for the determination of critical phenomena, can be identified respectively with

a) the unfolding of an infinitely degenerate state or q point,

b) an initial and infinite sequence of phase conjugate adaptive resonant events, and

c) with, by inference from Wolfram, a quantum computer universal attractor and the associated sequence of quantum computational behaviors,

such that (a) says, see section 6, an historical record, its Berry phase, is maintained in terms of phase, and where in the case of (c) the maintenance of this historical record by means of phase carries the implication that the attractor is quantum holographic, in line with the earlier postulate that Wilson's 3 dimensional spatial lattice rescaling procedure is realized by quantum holography.

That is to say, all three concern an essentially universal unstable fixed saddle point i.e. one between stable fixed points, where further evidence in support of all these being one and the same comes from

a) the feature of universal degeneracy. For this is also a characteristic of QH, which concerns up to a unitary isomorphism, infinite dimensional irreducible linear unitary

representations of the Schrodinger type of G, the 3 dimensional Heisenberg nilpotent Lie group, and

b) experimentally validated electro-weak theory in elementary particle physics in terms of the Weinberg/Salam angle. For this angle defines a change of phase $\Delta\theta$ of the reference frame at an unstable critical fixed point, in relation to the interaction from

(i) the unstable weak particles Bo and Wo, into

(ii) the stable electromagnetic photon γ and and its heavy neutral analogue Zo,

such that $\sin(\Delta\theta) = 1/\sqrt{5}$ [Close, 1982]

This quantum mechanical critical fixed point S can therefore correspond to the result of a unimodular unitary operation, discovered by Dubois and Resconi [1992], related to the Golden Number L, where L can be seen now as acting as a critical parameter in relation to S. That is to say this unimodular unitary operation could indeed relate to electro-weak theory, long thought likely to provide the basis for evolution, through such interactions, for example, as fission and fusion. Further this evidence of a possible unimodular unitary connection between classical and quantum mechanics, is supported by of the self-similar/fractal/holographic/wave nature of the interface observed in 2 dimensions at the computer generated boundary of the Mandelbrot set [Young, 1993]. In this connection it is also of note [Feigenbaum 1978] that many periodic systems, such as noisy oscillators, fluid flows, and biological populations, etc, which go through critical points and stable regions, show a parallel series of characteristic time periods T, 2T, 4T, 8T, ..and that the limit to such a series is aperiodicity, which mathematically manifests itself as chaos.

4 A Further Key to Understanding Critical Phenomena?

A further key therefore to understanding critical phenomena may be, remarkably, Riemann's Zeta function, identified by Berry [1986] with quantum chaos and now known from the work of Connes [Klarreich 2000] to specify a quantum mechanical system. This function, a means of turning all the integers n, or as Euler showed, all the primes p into another number via the complex amplitude $z = x + iy$, was the subject of a hypothesis by Riemann in 1859, still unproven, that all its non-trivial zeros lie somewhere on the real line $x = \frac{1}{2}$. The amplitude and phase of z therefore show that this famous hypothesis concerns a quantum wave phenomenon with a spectrum of fixed points defining fixed phases on this real line. That is, it can be postulated to define all the gauge invariant relative phases or Berry phase of some quantum state vector (up to some arbitrary constant phase factor), where all these spectral points are fixed points in relation to critical phenomena. A testable hypothesis of this paper is therefore, that the Zeta function concerns Wilson's [1983] experimentally validated use of the renormalization group procedure defining material phase transitions, such as liquid to solid, etc. That is, the critical fixed points (of Zeta) define properties of matter, noumena /qualia, where these, the renormalization group methodology says, concern the symmetry properties of groups. This would provide an irreversible mechanism for evolution in terms of all the unstable fixed points and symmetry breaking, such that physical degrees of freedom of the free energy F become phase unlocked at the unstable

fixed points of the evolution. It can then be asserted that all the zeros on the real line x = ½ , correspond to the fermionic states of spin ½ to which the Pauli exclusion principle applies. That is to say the postulate is that the zeros of the Zeta function define the phase conditions of fermionic indistinguishability/degeneracy where systems of fermions may act like a boson such as happens, for example, in low temperature superconductivity in relation to electrons when they form degenerate Cooper-electron pairs. This assertion is in agreement with the fact that this phenomenon of superconductivity only happens below some critical temperature, and is therefore indeed a material phase transition in accordance with the precepts of Wilson's methodology [1983] and its findings, in relation to quantum mechanical effects, described in terms of critical lengths/scales, etc, in dimensionality d = 1,2,3 or 4. It is in line with examples of the Berry/geometric phase in quantum mechanics, well known before Berry's work, which concern the rotations of a spinor. For technically the factor distinguishing integer and half integer spinors is related to the 1:1 and 2:1 representations of the 3 dimensional rotation group [Manini 2001]. It points to non-trivial topological properties underlying the relation between vector quantities and adiabatic parameters q in relation to the Berry phase, which concern, for example:-

i) either, fields such as, for example, the external magnetic field in relation to low temperature superconductivity, or

ii) some internal degrees of freedom of the system Hamiltonian H under investigation, where these maybe treated as "slow" classical variables, affecting adiabatically the "fast" quantum dynamics of the other degrees of freedom. Here "slow" means that the parameters q change only by small amounts, ie there is smooth dependence of H on the parameters q. Otherwise changing q from one point to another can lead to a totally new and unrelated eigensystem.

Item (ii) can therefore be interpreted as saying that the three spatial degrees of freedom (x,y,z) concern such "slow" classical variables, below some critical parameter which can therefore be postulated to be "the velocity of light", so that below this velocity or critical fixed point, quantum locality as opposed to non-locality applies in accordance with generalized Lorentz invariance. That is to say, above such a critical fixed point, not only would these spatial degrees of freedom lead to totally new quantum eigensystems, but their spatial character below this critical point could be regarded as a quantum physical property like those of mass, spin, charge, etc, as being a consequence of cosmological evolution. Such an interpretation then says :-

(a) that such "spatial" degrees of freedom correspond to quantum mechanical as well as classical properties,

(b) that this is in good accord with phase conjugate adaptive resonance in QH, where the condition of phase conjugation specifies points on the light cone and therefore the same critical fixed point concerning the "the velocity of light" c,

(c) that it would allow an extension of the standard model of the families of leptons and quarks, such as that proposed by Rowlands and Cullerne [1999]. For (b) does indeed concern the two symmetrical algebras of 4 vectors with real vector units **i**, **j**, **k**, and imaginary scalar i, and the quaternions with imaginary vector units *i, j, k* and real scalar 1, on which their model uniting respectively the symmetry properties of space/time and

charge/mass (where charge now includes strong, electromagnetic and weak) is based. This would, not only, as already argued here, explain all the properties of mass, charge, space and time as critical phenomena, but say that mass/charge is the totally new quantum eigensystem appropriate to time/space, when these may no longer be treated as "slow" classical variables. That is to say, the velocity of light c appropriate to special relativity in relation to Lorentz invariance, now appears, in the role of a critical fixed parameter, separating the local (classical) from the non-local in quantum mechanics. Thus in this proposed self-referential cosmology of a self-created universe as a critical phenomenon, the Rowlands /Cullerne model defines the nature of 3+1 space/time structural (holographic) stability, where

i) evidentially the least complex neutral space-time stable units concerning all these properties of mass and the strong, electromagnetic and weak charges are those of neutral hydrogen and helium, with 1 proton and 2 protons respectively in relation to the unstable weak nuclear reactions governing fission and fusion respectively, while the remainder in relation to such circumstances concern the stable and unstable isotopes of the periodic table, and

ii) similarly the cosmic time/space evolution of individual quantum fields in respect of mass and charge relates to their coupling constants. For these, it is known, are also an expression of the unstable critical fixed points, that concern, for example, gravitationally, $\cong 10^{38}$ unit hydrogen or proton masses; strong, 3 unit quarks (defining the baryons); electromagnetic, 137 units of Coulomb charge. These unit numbers are of particular significance in relation to the ANPA model of elementary particle physics known as the Combinatorial Hierarchy or Program Universe (see [Pierre Noyes 1999] for a recent in a long series published in the ANPA Proceedings often cited here], where as here, the emergence of Lorentzian space/time is a fundamental consequence following from the precepts of the Hierarchy, as first discovered by Bastin and Kilmister [1954].

iii) in relation to such neutral units of mass, the space/time 4 vector behavior is that an invariant mass scalar, or mass geodesic in 4 dimensions. This therefore conforms to the precepts of Einstein's theory of general relativity, as can also be proven in QH using Lie transformational theory, since QH is defined, as above, in terms of the 3 dimensional Heisenberg nilpotent Lie group. Furthermore it can now be inferred in relation to electromagnetic charge, that the behaviour of such fixed charged units must also conform to that of general relativity, as this is known to be the case in relation to the Klein Kalutza equation. Thus, the Rowlands/Cullerne model tells us that units of mass/charge including the zero units such electromagnetic quanta, correspond to null geodesics or sources/sinks of such 4 vector Lorentz invariant general relativistic space/time fields, so that in contradiction to the generally held view in physics that quantum theory and general relativity are incompatible, in fact the quantizations of mass, electromagnetic, strong, and weak charge in relation to the Rowlands/Cullerne extension of the standard model of elementary particle physics are exactly those that ensure such compatibility!! In these domains therefore spatial curvature and matter/charge would be the antithetic quantities, which cancel each other out, rather than, as is usually supposed, those of matter and anti-matter which are, of course,

transformable into energy. That is, space/time curvature and matter/charge can now be postulated to be the mechanism to explain how this postulated self-referential universe is enabled to create itself from an initial instability or unstable critical point, in terms QH would imply, of an incremental process of phase conjugate adaptive resonance. This requires the simultaneous creation of mass and space or their corresponding simultaneous destruction on various cosmological scales at such a critical point in accordance with Rowlands/Cullerne. Similarly Mach's equivalence principle in relation to mass and inertia in accordance with his global precept that existence of any particular mass in the universe is consequence of the existence of all the others masses, then follows as a consequence of the antithetic nature of mass/energy and time/space, and the fact that the Rowlands/Cullerne model says the mass is a non-local quantum mechanical property. These conclusions receive further support by the fact that Rowlands and Cullernes' [2001] generalization of the Dirac equation is nilpotent and can be expressed in terms of quantum creation and annihilation operators, and that spin and helicity in accordance with the accepted quantum precepts are also implicit in their model. A further conclusion since QH is specified in terms of the 3 dimensional Heisenberg nilpotent Lie group must therefore be that since Lie transformational theory and its methodologies are a means to determine 3 dimensional spatio-temporal invariants, that Lie groups, systems and their prolongations also constitute solutions compatible with general relativity and quantum mechanics. Such Lie transformational systems have been extensively used by Hoffman [1989] to model structure in the brain and the processes of perception and thought. Hoffman's little known work can therefore, here, be strongly hypothesized to be accurate, valid models of thought, the brain and neural structure warranting much more extensive study, since they are based on the stability criterion for spatio-temporal matter, as described here, that must also apply in all living systems and in particular in actual brains, as indeed should those of DNA.

Correspondingly the arbitrary constant phase factor in relation to geometric phase can be considered as the "ground state" of a cosmology, of which the Zeta function specifies in relation to spin/fermionic behaviour the critical fixed points, considered as the cosmology's eigenlevels (and gauge invariant phases) so as to specify all its material phase transitions. Thus this whole cosmology, like the hydrogen atom, is described by an infinite spectrum of eigenlevels, and can be pictured in the same way [Klarreich 2000]. But any cosmology, defining a universe in terms of its dictionary meaning "of all that exists", demands a "ground state", that cannot itself be measured, since there is nothing further to measure it against. That is to say, such a cosmos behaves self-referentially with respect to measurement. A fact known to be experimentally the case in relation to quantum vacuum phenomena such as those of the Lamb shift and the Casimir effect [Puthoff 1990].

This hypothesis of a self-referential cosmology is also in agreement with the hypothesis of Berry [1986], that there exists a quantum mechanical system of an unknown energy function/Hamiltonian without time reversal symmetry, whose eigenvalues are defined by the zeros of Riemann's Zeta function. Such an energy function with an arbitrary constant phase factor or un-measurable ground state, might also explain the supposed phenomenon dark matter, which some cosmologists, on the basis of the latest

astronomical observations, claim is in need of explanation [Caldwell and Kamionkowski 2001].

5 Living Systems

5.1 Models for the Basis of Life

It has been mentioned earlier in section 3, that in passing through phase transition points, water is marked by quantum mechanical effects/quantum coherent states on all scales from the atomic up to some correlation length. Thus at both the critical points concerning the gas/liquid and liquid/crystal (snow) phases of water, there will exist droplets on all scales containing quantum coherent water within which quantum self-interference and spontaneous phase conjugation [Noboli 1985;1987] will take place. That is to say such droplets as quantum resonant cavities would provide the conditions necessary for the quantum wave functioning of DNA as proposed independently by Marcer and Schempp [1996; 1997] and Gariaev group [2001], where the latter paper presents some of the Gariaev group's experimental evidence and computer simulations in support of their theoretical thesis that such DNA-wave computation/quantum holography is the basis for life.

Further evidence in support of this hypothesis is that it fits in a coherent and practical way with the currently existing scientific hypotheses and evidence, that recognizable life : -

a) began near the volcanic fissures in the ocean bed, where the simpler unstable critical point of the gas/liquid state of water is sustained, so as to foster, it can therefore be hypothesized, the formation of single celled prokaryote organisms and their chemistry as proposed see (d) below,

b) was enabled to develop into its complex many celled Eukaryote forms at the unstable critical point of the liquid/crystal (snow) phase during the correspondingly sustained period for which the geology of the recently hypothesized "Snowball Earth" theory now provides substantial supporting evidence. The many celled forms, rather than the single cell forms can be hypothesized to arise in this particular phase transition point as a consequence the more complex self-similar/holographic nature of the quantum coherence that must exist there as indicated by the universal fractal nature of snow flakes in relation to this unstable critical point,

c) would be generally sustained on sunlit water surfaces of all scales, oceans, seas, lakes, ponds, pools, puddles, down to drops. For such water surfaces facilitate quantum holographic transduction between the electromagnetic and the acoustic frequency domains, as Gariaev and his collaborators [2001] have demonstrated to be the case, during their investigations into wave bio-computation in DNA. Such transduction (of energy from the electromagnetic to the acoustic frequency domain leading to dynamical stable material structures) could therefore be hypothesized as the basis of photosynthesis and the evolution of chlorophyll for example. And it must here be hypothesized to govern the entire variety of functioning established by surface receptors between the outside and the inside of living cells.

d) all the recent evidence for optimally controlled quantum signal induced chemistry [Rice1992; Dahleh et al. 1990; Schleich 1999; Leichtle et al. 1998; Patel 2000] for example, as an alternative to standard thermodynamically controlled chemistry /"cooking". For example, the use of computers to teach lasers to control molecules, so as to optimize chemical reactions, has already been demonstrated in the laboratory [Judson and Rabitz 1992]. It constitutes the new possibility by means of coherent quantum signaling for the evolutionary development of optimally controlled chemical reactions such as are often found in living systems, and points to the need to reassess, for example, the 1952/53 experiments of Miller and Urey into the origins of life, where within a closed flask, unstructured electric discharges through a 'primordial Earth atmosphere' for many days produced a soup of the basic amino-acids important in living processes, but nothing more.

e) the fact that such material phase transitions not only produce new and previously unknown physical properties, but also concerns the free energy F at critical temperatures T. Such critical temperatures characterize many complex life forms, and lead to the expectation that life-forms, such as ourselves, based on critical fixed material phase transitions as hypothesized here, would become critical temperature self-regulating, so as to optimized the working and use of their free energy F, and so as to be able to function as quantum coherent wholes, rather than classical mechanisms, such as it is still generally assumed, by both molecular biologists and biologists that living systems are.

Indeed this fact could even be the unique factor regulating the appearance of the property – noumena/qualia of human consciousness; i.e. that it has, as is indeed observed, its own critical temperature, etc, which characterizes its human emergence, and optimal functioning.

It might be objected that such critical temperatures only occur, in principle, in the thermodynamic limit in a system with an infinite number of degrees of freedom. However, this in indeed what quantum holography with its infinite dimensional irreducible unitary linear representations of the Schrodinger type of G, in principle, has.

5.2 The Nature of Self-Referential Conscious Observers

If in a self-referential quantum holographic subsystem, an object were an observer capable of making observations [Marcer and Schempp 1996; 1997;1998a; Marcer and Mitchell 2001], these observations/measurements would, it has been shown have to be phase conjugate. That is, from the perspective of their own self-referential frame, such observers would perceive other objects, where they are actually located outside their own embodiment in 3 spatial dimensions, which is essential to survival and exactly the nature of human perception. Similarly, as has also been shown, the result of quantum measurements of such a observer's perceptions (its local Berry phase) constitute a generalized quantum holographic record that can be used :-

i) to define the human observer's experience ie the observer's perceptions, since such experience is indeed how each of us measures ourselves and our actions against some reference frame, be it that of the world/universe as a whole or some role model, and

ii) to define both the observer's awareness of that world/universe and conversely of its own bodily (and mental) self-awareness, ie the observer's own embodiment or body from the perspective of its own self-referential frame.

Thus human consciousness must, by implication from (i) and (ii) and further levels of self reference in regard to the human observer's own reference frame, be a very personal, i.e. one from the perspective of its own unique reference frame and history of experience. It includes in this model however the awareness of the human observer's actual quantum self or will, defined as the observer's own free (physical and mental) energy (this is however ultimately inseparable from that of the Universe as a whole!). For example, the mental free energy, which we all self-acquire naturally as a child (what we truly observe when a child is being willful), that is used to exert and then control or partially control our physical free energy and later our mental/thought processes themselves [Marcer and Schempp 1996]. That is to say how the human self controls its brain implies that brain itself has an neural object image or mental self, which we call the mind, which can be used to control the brain's quantum neural embodiment, and is used consciously as when, for example, starting to learn to drive a car, or in some act of great courage or folly, when such conscious control can be used to indeed override all the human being's established experience or norms, mental or physical. This prediction that the human organism has two principal self-reference frames, one physical and one mental associated respectively to its entire physical and neural embodiments, in respect to its physical and mental wholeness/health, is one for which Steckner [2001] has produced demonstrative and simple experimental evidence of their physical separation. The process of the spatial separation or evolution of mind frame or self from the whole body frame or Self, can therefore be postulated to have indeed taken place, as man's ancestors began walking on two legs, and can be seen in this light as a prelude to the emergence of human consciousness, as we know it. This model therefore postulates human consciousness to be a noumena/qualia of living systems that arises as the result of a higher level of self-reference now reached by cosmological evolution in relation to the Earth Biosphere and perhaps even in relation to that of the Cosmos as a whole, i.e. it is a quantum material phase transition, and an inevitable emergent property of such an evolution.

6 A Illustrative Mathematical Model of the Desired Cosmological Boundary Conditions

Having eliminated every possible solution to a problem,
That which remains, however improbable must be the truth.
Sherlock Holmes

The mathematical model, below, uses Schrodinger equation to illustrate that the boundary conditions always essential to a correct solution could indeed in this case be remarkable and be identified from the known considerations :-

    A) of Berry/geometric phase [Manini,http] with the totally degenerate quantum state of zero energy, or q point, and correspondingly

B) of QH [Schempp, 1993] with a quantum vacuum Bargmann-Fock emitter/
absorber model expressed in terms of annihilations and creation operators.

The postulate proposed is that the Hamiltonian H is zero in the Schrodinger equation for the state vector ψ considered to apply to the Universe as a whole, so that

$$ih\partial\psi/\partial t = H\psi = 0$$

There can therefore be no Schrodinger evolution of dynamic origin and this time invariance ensures that there is quite literally "no time like the present" just as we all experience it.

However it does not preclude, considerations of the Berry phase say, a cosmological evolution of entirely geometric-topological origin [Lloyd 2001], as is also the nature of our experience. For ψ is now a complex constant a ∈ T the complex torus group, and a standing wave. That is,

$$\psi = a = \exp(i\theta) = z/|z|$$

where z is any complex number, since normalization of ψ requires that

$$\psi\psi^* = \sin\theta\,\sin\theta + \cos\theta\cos\theta = 1$$
$$\text{where } \psi = \sin\theta + i\cos\theta : \psi^* = \sin\theta - i\cos\theta$$

It therefore follows that the phase θ corresponds to the Berry parameter/angle in the Berry parameter space. Thus θ which specifies an arbitrary constant phase factor, may take any continuum value to satisfy the normalization, and so ψ defines a totally degenerate state, where

(i)   the degeneracy would ensure a non-trivial loop in the Berry parameter space and measurable gauge invariant phases of the state vector ψ, so that there exists observable Berry phases θ,

(ii)   these observable phases point to non-trivial topological properties between vector quantities and adiabatic parameters q, and

(iii)   the θ space with the degenerate θ points removed is infinitely multiply connected – an astonishing geometric-topological concept, allowing θ to be continually updated, considerations of Berry phase [Resta, 1997; Manini 2001], say, by :-
   a) how long the system has been away from its initial state,
   b) where in three dimensional space it travelled, and
   c) what other quantum mechanical states were visited on route

so that θ constitutes a complete history or historical record of the system's evolution and

(iv)   this degeneracy of ψ allows θ to change discontinuously by arbitrary amounts, yet normalization shows that all solutions are equivalent up to a unitary isomorphism. An example in optical holography described in terms

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of a process u/|u| concerns the sudden change of phase known as the Gouy effect [Schempp 1992]. In QH this arises from the hidden symmetries of the metaplectic group Mp(1,R) which is group describing the automorphisms of G and forms a twofold covering of the symplectic group Sp(1,R). It can therefore be seen as a renormalization,

(v)   further ψ can always be normalized, so in this cosmology the fundamental problem of renormalization is solved.

ψ may also :-
(a) act as the reference wave in relation to QH, performing the function of the ultimate measurement standard in regard to the quantum holographic measurement process, and
(b) serve as a diffraction grating/filter in relation to holography in regard to the 1933 Dirac/Kapitza postulate recently validated [Bucksraum, 2001]. Noting that such standing waves have two intensity peaks per cycle.

Thus ψ specifies an *infinite dimensional parameter space standing wave set*, which in QH concerns up to a unitary isomorphism, unique infinite dimensional irreducible linear unitary representations of the Schrodinger type of G, where the equation for normalization above shows, there is complete phase entanglement. Such complete phase entanglement thus confirms that :-

(i)   since QH is Lorentz invariant [Binz and Schempp 2001] there will be both the spatial (and implicitly the temporal coherence) (indicative of the mathematical signature $\{+,+,+, - \}$) necessary in QH for full wave-front reconstruction,

(ii)   that in QH specified in terms of the 3 dimensional Heisenberg Group Lie Group G(x, y, z), the spatial measures x, y, z, can be regarded as three spatial fundamental degrees of physical freedom, which in relation to the Berry phase may be treated approximately as "slow" classical variables, as already postulated. That is, these measures x,y,z are indeed true quantum mechanical and not just classical variables and so could concern the mathematical signature $\{-,-,-, +\}$ in relation to quantum non-locality. This is confirmed by the facts that in QH there is both a retarded and an advanced standing wave set, and phase conjugate adaptive resonance specifies coordinates where the 3 dimensional object image and that of the object coincide and so takes place on the Minkowski light cone itself,

(iii)   that coupled circle maps, which are able to model chaotic oscillations more efficiently than ordinary (i.e. not incursive or hyperincursive) differential equations, could therefore be used to more generally describe θ. These maps are a tool to describe both synchronisation and adaptation/learning by Hebb-type rules [Bauer and Nartienssen 1991]. For example, in a model where one such mapping represents the phase dynamics of one system (a neuron in the brain, for instance) or a group of neurons, it has been observed that, depending on the coupling strength, different maps show correlated or uncorrelated behaviour, while the autocorrelation function remains flat as is

expected for a chaotic signal. Another example would therefore be the fundamental gauge fields of physics (general relativity, the non-Abelian electro-weak and chromo-dynamic quantum fields, etc). It says that the corresponding coupling constants (the gravitational, electromagnetic, weak, strong, etc) or "strengths", represent evidence of correlated or uncorrelated behaviour, as is generally postulated to happen in the course of any postulated cosmological evolution.

Correspondingly in QH, the postulated cosmology would :-
(i)   take place by spontaneous phase conjugate adaptive resonance,[Noboli 1985; 1987] in bounded systems, which the cosmos/universe defined as all the exists, can be assumed to be,
(ii)   be described [Schempp 1983] through the linear Schrodinger representation U of G as a quantum vacuum Bargmann-Fock emitter/absorber model expressed in terms of annihilation/creation operators, a, a^* , where the number states $|n(k)\rangle$, which are the quantum states occupying the mode k, are the eigenstates of the number operator $N(k) = aa^*$ and $[a, a^*] = \pi$ is the bosonic commutation relation, and
(iii)   be described as a Lie transformational system, which in terms of its Lie diffeomorphism, or differential mapping with a differential inverse, confirms the conclusions reached concerning the geometric/topological nature of its behaviour and its renormalizability.

That is to say, in QH, where the phase θ is the quantity of physical significance, a repeated cycle of adaptive phase conjugate resonance describes the means by which the cosmology evolves. This results from the fact that θ adaptively maintains a complete history or historical record of the cosmology from the postulated totally degenerate zero energy quantum vacuum state, which existed before the initial spontaneous phase conjugate adaptive resonance, and which will partially continue to exist so as to initiate each following cycle, such that :-
(i)   the system/cosmology can never return to its initial state so satisfying the Third law of Thermodynamics,
(ii)   in each phase conjugate adaptive resonant cycle, QH shows that entropy acts as a quantum holographic information metric [Zurek 1989; Coveney, Jessel and Marcer, 1991] so satisfying the Second Law of Thermodynamics,
(iii)   this is an adiabatic process appropriate to QH, and the Berry/geometric phases θ such that the First Law of Thermodynamics holds during each cycle,

The concluding inference can therefore be that the proposed self-referential cosmology
i) functions as a quantum harmonic oscillator, since it is known that such oscillators are equivalent to an assembly of bosons each having one polarization state, and
ii) that its totally degenerate initial vacuum state is a totally squeezed state, since it known that oscillations in a photon (boson) distribution of squeezed states and interference in phase space concerns the fact that a single mode of the electromagnetic

field in a number state is equivalent to a harmonic oscillator with dimensionless co-ordinates p and q such the trajectories are circles with radius $\sqrt{2}(m+1/2)$ traversed in a clockwise direction and such that the area 2π(in units of h) are defined by an inner radius $\sqrt{2}m$ and an outer radius $\sqrt{2}(m+1)$, establishing the connection with coupled circle maps and complete phase entanglement.

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