The Analog-In, Digital-Out Universe

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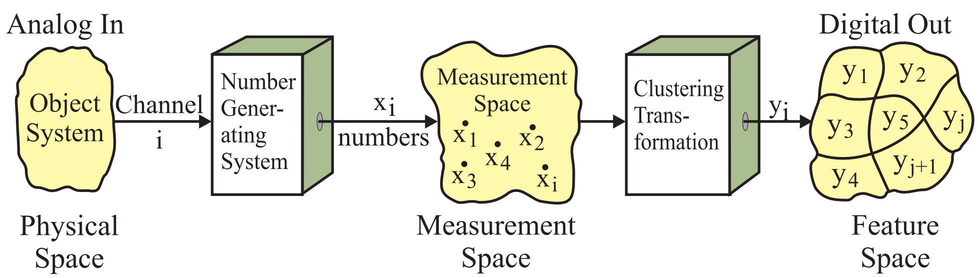
Abstract

Is Reality Analog or Digital? Analog and digital mathematical treatments can be shown to be equivalent, so the answer does not lie in math but in physics. At root is the nature of *particles* and *fields*. The simplest possible physical model, *one field*, will be analyzed and *physical experiments proposed* to show an analog reality with digital consequences. There are implications for the view of reality currently associated with entanglement and violation of Bell's inequality.

Physics is a discipline that is approximately based on the following diagram:



An appropriately isolated object system, measured by an appropriate number generator, produces a measurement space upon which clustering transformations can be performed—by either neural or silicon networks—to create a feature space that can be represented[1] in either continuous or discrete formalisms [*appendix A*]. Steiglitz has shown[2] the equivalence of time-invariant realizable analog filters and digital filters, so *the theory of processing analog signals and the theory of processing digital signals are equivalent*. Thus analog or digital reality questions can't be answered mathematically—the answer <u>must</u> be found in a *physical universe*. The simplest possible universe would consist of <u>one</u> primordial field $\phi(\vec{x})$.

Laws of Physics: Physics should *never* accept anything "outside time and space", such as: God, a mathematical universe, a multiverse, laws of physics, more than 4 dimensions. If physics does not grant God legitimacy, it should reject <u>all</u> other appeals to "the beyond". If only a *primordial field* exists initially, then any *law of physics* <u>must</u> derive from the field itself. Any operator ∇ applied to the field can only be construed to represent the field interacting with itself, so the symbolic Master equation representing this reality is

$$\vec{\nabla} \cdot \vec{\phi} = \vec{\phi} \cdot \vec{\phi} \qquad (1)$$

where the dot represents interaction. Since one cannot derive physics from logic, we need physical facts: Maxwell's energy $\sim \phi^2$ and Einstein's energy $\sim m$. These suggest that $\vec{\phi}$ is gravity, $\vec{G}$, so $\vec{\nabla} \cdot \vec{G} = -m$ [*appendix B*], and operator $\vec{\nabla}$ is a *directional derivative* or *tangent vector* definable in any local coordinate system on a manifold (including Calabi-Yau).

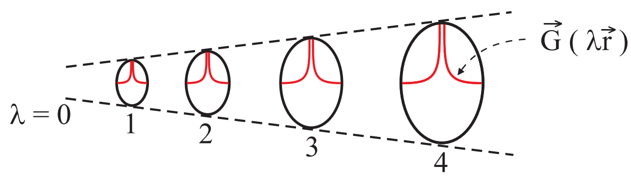
So we need math, but where does math come from? The $\vec{\phi}$ *-field* will support particles from which structures[3] that generate integers are built, and, per Kronecker, *man can produce the rest of math*—so we needn't go *outside* the universe for math[4] but can *use* math to solve the Master equation, yielding $\vec{G} = \vec{r} / r^2$ hence $\vec{G} \cdot \vec{G} \Rightarrow |Gr|^2 = 1$. In 1953 Eugenio Calabi essentially asked if our Master equation was valid:

> *"Could there be gravity … even if space is a vacuum totally devoid of matter?"*

He reasoned: "…being non-linear, gravity can interact with itself and in the process create mass", and he conjectured, "*curvature makes gravity without matter possible*". The Calabi-Yau manifold confirms[5] our Master equation—based only on gravity —but his conjecture was based on special geometry in which "time is frozen". Meaning what? Newton's equation is time independent, but if we scale $r \to \lambda r$, then $\vec{G}(\lambda\vec{r}) = \lambda^{-1}\,\vec{G}(\vec{r})$ and our Master field equation is seen to be scale invariant (*appendix C*):

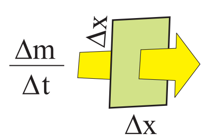
$$r \to \lambda r \qquad \Rightarrow \qquad \lambda^{-1}\vec{\nabla} \cdot \vec{G} = \lambda^{-1}\vec{G} \cdot \vec{G} \tag{2}$$

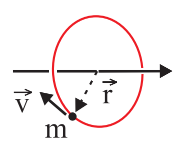
Nottale has shown[6] that the laws of scale can actually take the place of the laws of motion: that is, *scale invariance* implies *motion invariance* ($t \leftrightarrow \lambda$). This can be visualized as:



If *scale invariant* is *motion invariant,* time has no obvious meaning. But action orthogonal to a radial field vector can produce a *vortex* or cyclical phenomenon in a region of space, introducing *duration* or *cycle time*. So time appears when the $\vec{G}$ -field symmetry breaks and local oscillations, i.e. natural clocks, occur. The *time dependent* phase occurs as *symmetry breaking*; thus *formal* time dependence[4,8] of the solution $|Gr|^2 = 1$ yields [*appendix D*]:

$$\left(\frac{\Delta m}{\Delta t}\right)(\Delta x)^2 + 2mvr = 0$$





This equation and two possible physical interpretations (shown) make sense only if both terms have a constant value, call it $\hbar$, leading to the quantum principle:

$$\vec{\nabla} \cdot \vec{G} = \vec{G} \cdot \vec{G} \qquad \textit{Classical Field equation - continuum physics} \tag{4}$$

$$\Downarrow$$

$$\frac{\Delta m}{\Delta t}(\Delta x)^2 = \hbar \qquad \textit{Quantum Principle - physics of observables} \tag{5}$$

This generalization of Heisenberg's uncertainty principle also implies $mvr = \hbar / 2$, Bohr's orbital condition. Nottale says "*it's remarkable that the Heisenberg relations are universal* *and independent of any particular measurement process*" and claims[6] the relations imply a 'profound scale dependence' of physical laws in the quantum domain. To see what scale is associated with a local mass m, let $\Delta m = m - 0$ and solve: $\Delta x = \hbar / m(\Delta x / \Delta t)$. For fixed mass, scale is min when $\Delta x / \Delta t$ is max ($\Delta x / \Delta t = c$, the speed of light) so $\Delta x = \hbar / mc$ is the *Compton wavelength* of the mass, the fundamental limitation on measuring the position of a particle. FQXi asks: **What do minimal length, time, or energy imply?** The Planck units of mass, length, and time yield an identity that implies our *Quantum Principle*:

$$\frac{\Delta m}{\Delta t}(\Delta x)^2 \quad \Rightarrow \quad \underbrace{\left(\sqrt{\frac{hc}{G}} \Big/ \sqrt{\frac{hG}{c^5}}\right)}_{(\Delta m \,/\, \Delta t)}\underbrace{\left(\sqrt{\frac{hG}{c^3}}\right)^2}_{(\Delta x)^2} = h \tag{6}$$

FQXi also asked: **How is time affected by quantization?** A change in time with respect to space, $\rho \approx (\Delta x)^3$, relates the mass gradient across the region, in $\hbar$ units. So *a quantum gravitational gradient implies time dilation:* (*appendix E*).

$$\Delta t = \hbar^{-1}(\Delta m \Delta x^2) \quad \Rightarrow \quad \partial_\rho(t) = h^{-1}\partial_x(m) \tag{7}$$

C-field physics: A classical field plus time dependence leads to a quantum of action, $\hbar$, that enables a fluctuation orthogonal to the field's radial symmetry, and introduces a *rotational aspect* of the primordial field $\vec{G}$, viewed as a new field, $\vec{C}$. Maxwell noted the $\vec{C}$-field analogy with the magnetic field $\vec{B}$ and wrote gravito-electro-magnetic equations [GEM], which I've modified (*appendix F*) with $\vec{\nabla} \times \vec{G} = 0$ and

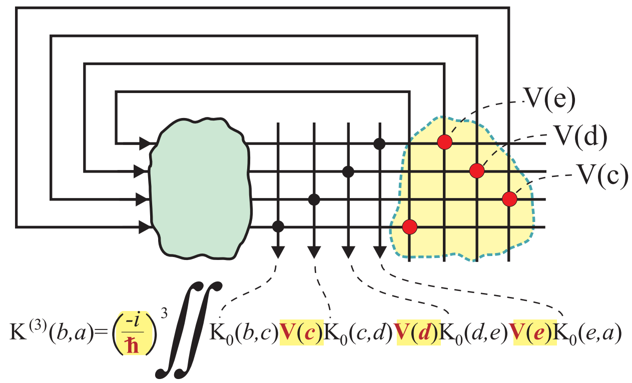
$$\frac{c^2}{\kappa}(\vec{\nabla} \times \vec{C}) = \frac{\vec{p}}{\mu} - \frac{d\vec{G}}{dt} \tag{8}$$

where $\kappa \approx 10^{31}$ is a dimensionless factor—derived[8] from reasonable assumptions—that Tajmar has also measured[9]. A Lorentz-like [$\vec{F} = m(\vec{G} + \vec{v} \times \vec{C})$] force provides $\vec{v} \times \vec{C} = -\vec{G}$, yielding natural *antigravity* for an *inflationary* big bang. And, from (8), ignoring gravity, if $\vec{\nabla} \times \vec{C} \approx \vec{p}$, then a change in the C-field circulation

$$\frac{d}{dt}(\vec{\nabla} \times \vec{C}) \approx \frac{d\vec{p}}{dt} \tag{9}$$

produces a Lenz-Law-like force that conserves linear momentum, solving Feynman's mystery[10]. Angular momentum conservation is built in via $mvr = \hbar / 2$ and C-field circulation is inextricably linked to local momentum since $\vec{C} \approx \vec{p} \times \vec{r} \Rightarrow \vec{\nabla} \times \vec{C} = 2\vec{p}$.

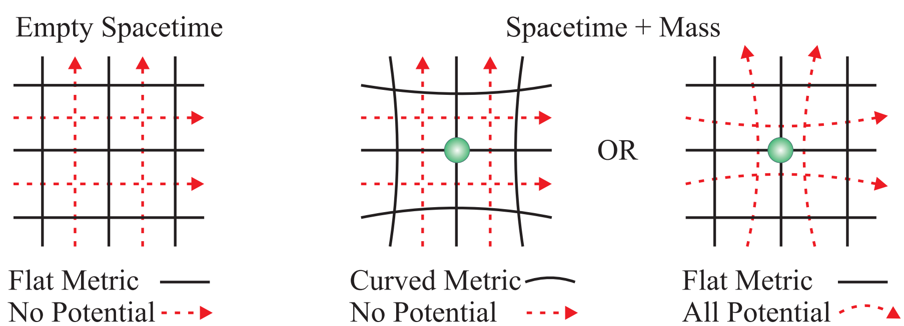
FQXi: **Does quantum nature imply** the world can be modeled as **digital computation?** *The Automatic Theory of Physics* states: "*All axiomatized theories of physics can be formally mapped into automatic machine representation.*" A typical 3rd order Feynman diagram[1] quantum field theory kernel $K^{(3)}(b,a)$, shown below in canonical form, maps the automata's *Next State-address* into *local potential* in physics.



Approaches to Physics: Entities can count, so math evolves, set-theory arises, topological connections appear, distance induces metric on topology, repetition yields symmetry groups and physicists fall in love with such. Approaches to physics are *metric* and *potential*—physics is split into two mapping schemes: *General Relativity* and *Quantum Mechanics*. An example of a *potential* description is represented by the GEM differential equations shown below at left, the *metric* solution by the tensor at right: [abbrev. - appendix J]

$$\begin{bmatrix} \vec{\nabla}\cdot\vec{G} = -m \\ \vec{\nabla}\times\vec{G} = 0 \\ \vec{\nabla}\cdot\vec{C} = 0 \\ \vec{\nabla}\times\vec{C} = \Delta\vec{m}/\Delta t - \Delta\vec{G}/\Delta t \end{bmatrix} \qquad \tilde{F}^{\mu\nu} = \begin{pmatrix} 0 & G^1 & G^2 & G^3 \\ G^1 & 0 & -C^3 & C^2 \\ G^2 & C^3 & 0 & -C^1 \\ G^3 & -C^2 & C^1 & 0 \end{pmatrix}$$

Their equivalence is seen in Sweetser's view[11] of metric and potential maps:



We can derive relativity's FLRW equation from GEM C-field equations, or we can derive the gravito-magnetic equations from general relativity. The need for *metric maps* arises only if tangent vector ∇ changes because the manifold we're moving on is in curved space. But both *metric* and *potential* approaches have drawbacks—general relativity defines[5] only global mass, so "*mass density is ill-defined in general relativity*". Yet μ in (8) depends upon local mass density. Other *metric* problems include: dark matter and energy; Second Law entropy; 'flat' space; flat rotation curves; CMB 'axis of evil'; etc., whereas problems for potentials derive from 'point particles' and from the fact that *scattering data fixes the strength and range of the nucleon potential, but not its shape*. As a result[29]:

> *The Lagrangian formulation provides a convenient technique for* <u>*inventing*</u> *new types of fields and investigating their properties.*

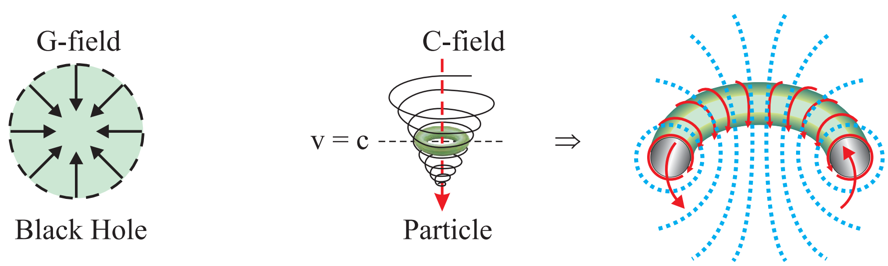
The mathematical *invention of fields* offers no guarantee the fields physically exist. But it does allow the invention of *Higgs, axions, dilatons, inflatons, anyons, instantons, WIMPs , sphalerons, gluons*[26]*, and SUSY particles*. None of these have ever been seen. [*appendix H*]

Particles and Fields: Physicists also form 'effective' potential fields from statistical combinations of particles and then they treat these fields as 'real':

- *Hartree-Fock*[28]*:* atomic electrons averaged; viewed as a field.
- *Dark matter particles*: viewed as a distributed field.
- *Einstein photons*: viewed as *Maxwell's* electric field.
- *Yukawa's pion exchange*[12]*:* viewed as the strong field.

The 'field' serves as an *approximation* that allows an unsolvable N-body problem to be solved as 1-body in a potential. Yet after 80 years of *pion exchange,* Wilczek—father of QCD— says[12] that *Yukawa pion exchange* fails at hard core distances. With all of these choices of *representation* for the many models, it's no wonder physicists are confused about particles and fields—both because Lagrangian techniques allow fields to be invented freely, and because *particles* and *fields* are *interchangeable* in QED [*but see Appendix I*].

Particles from a field: How can we derive *real* particles, distinguishable from a *real* field? We need a final assumption: *that the curvature of space is limited.* Without a limit, space can curve in upon itself to produce infinitely dense mass points—limits prevent this. *Electrons* and *quarks*[8,21] appear as limits to the curvature of $\vec{C}$, and *black holes* as limits to the curvature of $\vec{G}$. Limiting phenomena are defined by mass, charge, and spin:



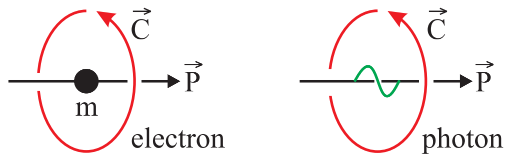
When the C-field reaches the limit of curvature, the vortex wall is a mass current loop, inducing a secondary C-field circulation and converting to a torus topology, a Calabi-Yau manifold[5] (Kähler, Ricci-flat with Chern class 0) supporting spin ½, containing *SU(n)* symmetry, and regarded as a solution to Einstein's differential equations.

***Are* particles and fields interchangeable**, as assumed in standard models, or does a field—a fundamental continuum—condense into discrete particles when curvature limits are reached? Yang-Mills C-field vortices[8] condense to Majorana neutrinos, electrons, and quarks, and supply the mechanisms of weak and strong forces—all derived from C-field.

Local Reality: Are these neutrinos, electrons, and quarks locally *real*, or are they *superpositions of states*? deBroglie, Schrödinger, Einstein, and Dirac preferred a 'particle plus pilot wave' view—compatible with two-slit experiments and entanglement phenomena. Both electrons and photons possess momentum, so the C-field circulation $\nabla \times C \approx p$ applies to both and implies a real *particle* with a Lenz-law-like *pilot wave*:

Particle plus pilot wave:

$$\psi(\vec{r}, t) = \psi_0 \, e^{i\hbar^{-1}(\vec{p}\cdot\vec{r} - \hbar C t)}$$



The parameters for particle plus pilot wave—momentum $\vec{p}$ and field $\vec{C}$— provide the standard free particle solution to Schrödinger's equation and support Bohr's principle of particle/wave complementarity. *Collapse of the wave function* is not part of QM—it's an add-on[7]. Although the consensus among physicists seems to be that local reality doesn't exist, recent *Physical Review Letters* papers[13, 25] state the factual truth:

> *"…no experiment ever closed both the locality and the detector-efficiency loopholes to conclusively rule out local hidden variable theories."* [and] *"A finite amount of data cannot conclusively demonstrate entanglement."*

Momentum-induced C-field circulation, as local hidden variable, has never been ruled out—or even explored. *Superposition of states* is a *consensus interpretation*, not a physical fact. *Collapsing wave functions* imply to some that particles exist as 'probability waves' when not observed. But analog inputs applied to classical electron orbits—unlike jumps associated with quantum inputs—should 'smear' the orbit—*exactly what is found*. And interpretation as a 'superposition of states' rather than a 'smeared orbit' is challenged by recent[14] *non-dispersing Bohr orbits* in which the electron behaves as a localized particle orbiting the nucleus in a classical orbit. This makes sense for analog disturbances applied to *locally real* particles with circulating C-field proportional to momentum: $\nabla \times C \approx p$. Non-dispersing Bohr orbits argue for *real* particles and *analog* fields.

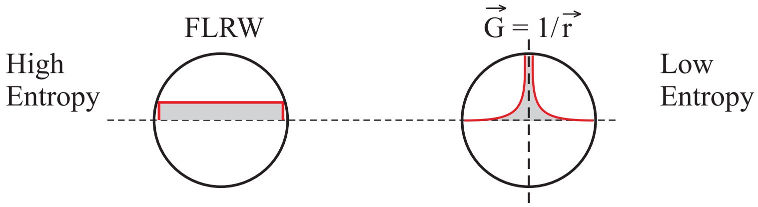
While entanglement has no known mechanism (spooky being the universal term of reference), in GEM, the C-field is the physical medium of entanglement with implications for locality and reality. The quantum mechanics of a particle with mass m and charge q in an electromagnetic field, $E = \nabla\phi - c^{-1}\partial A/\partial t$ and $B = \nabla \times A$, is formulated in terms of potential vector A (despite A being indeterminate within gauge invariance), and the Hamiltonian is based on momentum $p - (q/c)A$ instead of simply $\vec{p}$. But whereas quantum mechanics of free particles and atomic electrons are well represented by $\vec{p}$ we find $\vec{p} = (\mu c^2/\kappa)(\nabla \times C)$ has μ dependent on local mass density. And unlike free particles, photons encountering beam splitters can experience variations in local mass density.

Zeilinger explains[15] Bell's inequality based upon properties of sets of twins with different hair and eye colors and heights [appendix G]. He shows how statistical inequalities are derived based on these properties, and concludes that experiments showing violation of Bell's inequality imply that *such properties do not exist until measured*. This radical conclusion is the basis of today's *rejection of local realism*.

But there is a simple alternative to his analysis. If one or more twins dyes his hair enroute, Bell's inequality *will* be violated, yet local realism exists. Solar neutrinos change enroute from the sun; why not photons? A GEM explanation is compatible with such entanglement. Many physicists are enamoured of entanglement's 'spookiness' and relatively unbothered by *non-local non-real* reality, but if local properties can change enroute, their arguments fail. If Zeilinger's explanation of Bell's inequality is valid, GEM is compatible with local realism.

GEM physics supports the local realism that the great physicists insisted upon.

C-field Cosmology: If the entire universe evolves from our Master equation, we need not only *particles* but *cosmology*. Penrose claims[16] big bang entropy—while scale invariant—*must* be minimal due to ever-increasing entropy. But all of general relativity's homogenous FLRW models with high entropy 'dust' fail this criterion. Yet most field-energy-mass of our G field is near the $\vec{r}=0$ singularity, thereby achieving the required minimal entropy:

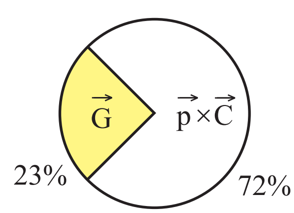


The universe's expansion is in striking accordance with Einstein's general theory of relativity, "*but only if two somewhat unexpected ingredients are incorporated…dark matter and dark energy*." We can derive[17] the FLRW equation at left from (8) and compare:

$$\frac{\ddot{a}}{a} = -\frac{1}{3}(\mu_G + 3p) + \frac{C^2}{3} \qquad\qquad \frac{\ddot{a}}{a} = -\frac{1}{3}(\mu_G + 3p) + \frac{\Lambda}{3} \qquad (10)$$

The general relativity version at right implies that *C-field energy* is Einstein's *cosmological constant* Λ, responsible for late inflation. If only 5% of C-field energy condenses to particles then 95% of C-field energy of the universe remains *uncondensed*. Directed entities G, v, C add and subtract: $v \times C \approx -G$ is inflationary, hence *dark energy*; but $v \times C \approx G$ augments gravity, hence *dark matter*. But $v \times C$ is equally distributed in all directions, while G is directed to the 'center' of the mass distribution. At any location approximately ¼ of $v \times C$ is additive (dark matter) while ¾ is subtractive (dark energy) as shown below:

100% = C-field universe, partitioned as:
5% = condensed $\vec{C}$ as particle mass
95% = uncondensed $\vec{C}$-field, seen as:
23% = 'dark matter' $v \times C \approx G$
72% = 'dark energy' $v \times C \approx -G$



Is the *dark matter* comprising most of the Universe a *field* or *particles*? Many different particles have been proposed as dark matter, but *all* of them should become trapped in the Sun's gravity well[18]. If dark matter is a continuous *field* the sun should show it—thus an *experimental test* should be able to distinguish an analog C-field from particulate (digital) dark matter.

> *"Gravity at large distances poses some of the most difficult puzzles in contemporary gravitational physics…"*[19]

These puzzles include the *cosmological constant*, the nature of *dark matter*, *flyby anomalies*, the *Pioneer anomaly* and Rubin's *flat rotation curves* seen in galaxies and clusters, as well as the CMB *axis of evil*. All are *unexplained by general relativity*. The C-field qualitatively explains them and now (19 Nov 2010) Grumiller provides[19] numbers needed for quantitative analysis. With natural units $\hbar = c = G_N = 1$ and $\Lambda = 10^{-123}$, he reports the scale of observed anomalous accelerations is $a \sim 10^{-62}..10^{-61}$: with *spiral galaxies*$\sim 10^{-62}$; *Galaxy-Sun* $\sim 10^{-62}$; *Sun-Pioneer spacecraft* $\sim 10^{-61}$; …while *Sun-Mercury* and *Earth-satellite* may be larger.

If C-field energy C^2 in (10) is identified as the cosmological constant, then $\Lambda = 10^{-123}$ says that $C \approx 10^{-61.5}$—*almost exactly* the acceleration needed to explain these phenomena via $\vec{a} = \vec{F}/m = \vec{v} \times \vec{C}$. Grumiller: "*It is a challenging open issue to understand precisely what determines the scale of* a." While general relativity *can't handle* mass density the C-field depends on local mass density via μ in (8) and this *can* explain variation in the scale of a.

Finally the LHC has surprised physicists/cosmologists[20] that the early universe was a 'perfect fluid', not an 'explosion of gases' that is the basis of all current theories. Our Master equation describes[4] a perfect fluid, a G-C-field yielding the most complete explanation of our universe for all known particles and cosmological phenomena—that is compatible with SU(n), Yang-Mills, Calabi-Yau, 3D space and time, and local realism.

The following physical experiments should establish the analog-digital nature of reality:

- ☑ *Measurement of the C-field to demonstrate its reality*
- ☑ *Non-dispersing electron orbits demonstrate the digital nature of particles*
- ☐ *A solar test of 'dark matter' to demonstrate the analog reality of the C-field*

Summary: Today relativity and quantum mechanics can't explain *the known particles* of physics. GEM theory does and predicts *no new particles*, based on a *particle plus pilot wave* model that is QM-compatible. Nor can general relativity and quantum mechanics handle serious problems such as the following, explained[21] in *Physics of the Chromodynamics War*.

- *Why does QED fail to get within 4% of the proton radius (in muonic hydrogen)?*
- *Why is the core of the neutron negative?* (*QCD predicts positive*).
- *Why are there three particle families?*
- *Why does the* J/ψ *decay into* 3γ*?*
- *Why do 6 deuterium quarks not collapse to a sphere, but maintain 'cigar' shape?*
- *Why does an electron exist in a non-dispersing (classical) orbit?*
- *Why can't QED derive the 'fine structure constant' – GEM can.*
- *What explains relative mass order of: electron, up, down quarks?*
- *Why are Halo neutrons stable beyond the range of the strong force?*

Again and again GR fails to cope with cosmological phenomena because of its geometrical—essentially static—treatment of curvature of space, well adapted to radial gravity fields. Einstein tried and failed[27] to solve the simplest C-field dipole—the gravito-magneto-static problem, and (aside from 'frame dragging') few have ventured here. General Relativity is beautiful, but inappropriate for Yang-Mills/Calabi-Yau instances of self-interacting C-fields, failing to explain Rubin's *flat rotation curves*, dark matter, dark energy, and CMB axes, while the actual 'flat' curvature of our universe limits *G*-curvature issues to black holes and neutron stars, and, even then, rotating bodies will induce the C-fields seen in jets.

If Tajmar's measurement of the C-field and my calculations are correct, the C-field explains physics mysteries via a *real*, not an *invented*, field. And not just one mystery, but dozens of mysteries. Fields and particles are *not* interchangeable, as is the case in quantum field theory. C-field *vortex* bosons induce local condensation of *real* massive left-handed Majorana neutrinos. Yet this cosmological and particle physics explanation for current physics is far simpler than many physicists wish it to be because, as Robert Godwin says[22]

> *One begins by abstracting from concrete existence,*
> *and ends by attributing concreteness to the abstraction.*

Perhaps due to lack of new particle physics for 40 years—many physicists have moved deep into abstraction and away from reality, attributing reality to abstract mathematics, making acceptance of a simpler physical theory that much harder. But failure of Higgs, SUSY, dark matter particles, etc to appear might eventually force reconceptualization on physics.

And the cosmological 'fly-by' mysteries aren't going away…

Assuming a primordial field—*and nothing else*—yields the major physics equations and conditions, with low initial entropy, and explains *all known particles*[8] sans Higgs. Quantum conditions—Bohr's orbital momentum and generalized Heisenberg principle—derive from a continuous field, implying an *analog* and *digital* world. A primordial (gravity) field, initially self-subject to a Master equation, whose scale invariance implies motion invariance until symmetry breaks, forms vortex phenomena that lead to the evolution of the Universe as we know it. A continuous universe evolves to discrete reality, where quantum conditions carve up the continuum, such that *analog inputs occasion digital outputs* or threshold crossings. Finally, the real field supports particles with properties compatible with local realism, and explains how Bell's inequality is violated with no consequence for local realism.

Physical reality depends on continuous fields.

Informed reality depends upon the existence of thresholds, or universal constants.

$$\vec{\nabla}\cdot\vec{\phi} = \vec{\phi}\cdot\vec{\phi}$$

$$\Downarrow$$

$$\partial_{\rho}(t) = \partial_{x}(m)$$

space time distance mass

Beauty is truth,
truth beauty, and that is all
Ye know on earth,
and all ye need to know.
Keats

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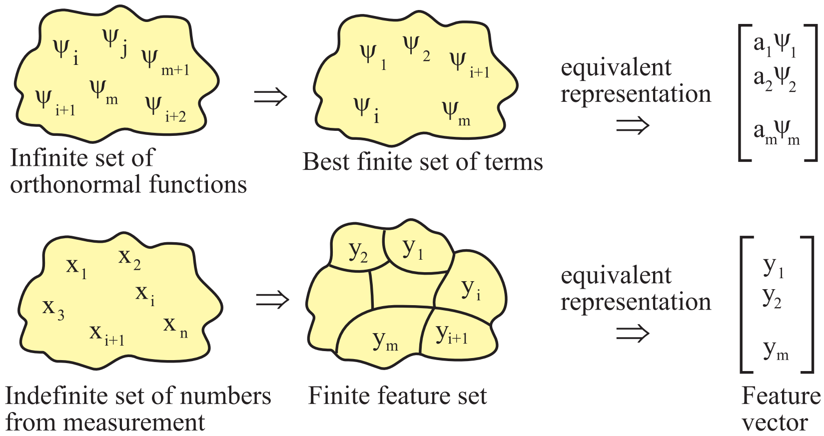
27 Pais, *Subtle is the Lord: Albert Einstein*, 1982 ISBN 978-0-19-280672-7
28 Fischer, *The Hartree-Fock Method for Atoms*, 1977 ISBN 0-471-25990-X
29 Goldstein, *Classical Mechanics*, 1959 Lib of Congress 50-7669

Appendix A: *The Derivation of Theories of Physics from Numbers*: *The Automatic Theory of Physics* describes how continuous functions can be mapped onto a feature set derived from numerical measurements as represented below:



The following five questions are answered in detail:

- Q1 How to reduce an indefinite number of measurements to finite number of features.
- Q2 What is the criterion for "best" feature set?
- Q3 How can we *obtain* the best feature set?
- Q4 How will we describe the dynamical behavior of the object?
- Q5 What is the best physical theory?

Appendix B: *Derivation of Newton's equation from the Master equation*: Maxwell: energy $\sim \phi^2$ and Einstein: energy ~ *m*, suggesting $\vec{\nabla} \cdot \vec{\phi} \approx \phi^2 = energy \approx m$. If $\vec{\phi}$ is gravity, $\vec{G}$, then energy is negative, and formal equivalence to Newton's gravitational equation: $\vec{\nabla} \cdot \vec{G} = -m$, implies that $\vec{\nabla}$ is the *directional derivative*.

Appendix C: *Demonstration that the Master equation is scale invariant*: The field configuration determined by solving the Master field equation is $\vec{\phi} = \vec{r} / r^2$. If we rescale $\vec{r}$ we obtain (for $\vec{r} \to \lambda \vec{r}$) then $\vec{\phi}(\lambda \vec{r}) = \lambda \vec{r} / \lambda^2 r^2 = \lambda^{-1} \vec{r} / r^2 = \lambda^{-1} \vec{\phi}(\vec{r})$

Since $\vec{r} \to \lambda \vec{r} \quad \Rightarrow \quad \vec{\phi}(\vec{r}) = \lambda \vec{\phi}(\lambda \vec{r})$ the solution field configuration is scale invariant according to Wikipedia's requirement: $\vec{\phi}(x) = \lambda^{-\Delta} \vec{\phi}(\lambda x)$. But we've yet to show that our field equation is scale invariant. We do so by replacing the original field $\vec{\phi}(\vec{r})$ with the rescaled field $\lambda \vec{\phi}(\lambda \vec{r})$ in the equation $\vec{\nabla} \cdot \vec{\phi}(\vec{r}) = \vec{\phi}(\vec{r}) \cdot \vec{\phi}(\vec{r})$.

Scaled: $\vec{\nabla} \cdot (\lambda \vec{\phi}(\lambda \vec{r})) = \lambda \vec{\phi}(\lambda \vec{r}) \cdot \lambda \vec{\phi}(\lambda \vec{r}) \quad \Rightarrow \quad \vec{\nabla} \cdot \vec{\phi}(\lambda \vec{r}) = \lambda \vec{\phi}(\lambda \vec{r}) \cdot \vec{\phi}(\lambda \vec{r})$

$$\vec{\nabla} \cdot \left(\frac{\vec{r}}{\lambda r^2} \right) = \lambda \, \lambda^{-1} \vec{\phi}(\vec{r}) \cdot \lambda^{-1} \vec{\phi}(\vec{r}) \quad \Rightarrow \quad \frac{1}{\lambda} \vec{\nabla} \cdot \vec{\phi}(\vec{r}) = \frac{1}{\lambda} \vec{\phi}(\vec{r}) \cdot \vec{\phi}(\vec{r})$$

Appendix D: *Derivation of Quantum Principle from the Master equation*: The Master equation solution is $\vec{G} = \vec{r} / r^2$ hence $|Gr|^2 = 1$. The formal change with respect to time $\frac{d}{dt}(G^2 r^2) = \frac{d}{dt}(-mr^2) = \frac{d}{dt}(1) = 0$, hence $-\frac{dm}{dt}(r^2) - 2mr\frac{dr}{dt} = 0$. This yields $(\Delta m / \Delta t)(\Delta x)^2 = -2mvr$ which is only generally true if both sides are constant, $\hbar$, leading to the *Quantum Principle* and *Bohr's orbital condition*.

Appendix E: *Time dilation derived from the Master equation*:

$$\frac{\Delta t}{(\Delta x)^3} = \frac{1}{\hbar}\left(\frac{\Delta m (\Delta x)^2}{(\Delta x)^3}\right) \Rightarrow \partial_\rho (t) = h^{-1} \partial_x (m)$$

Appendix F: *Summary of the GEM equations derived from the Master equation*: The G and C field equation's are Yang-Mills self-interacting as required for strong field physics.

$$\begin{bmatrix} \vec{\nabla} \cdot \vec{G} = -m \\ \vec{\nabla} \times \vec{G} = 0 \\ \vec{\nabla} \cdot \vec{C} = 0 \\ \vec{\nabla} \times \vec{C} = \Delta \vec{m} / \Delta t - \Delta \vec{G} / \Delta t \end{bmatrix} + \begin{bmatrix} \vec{\nabla} \cdot \vec{E} = q \\ \vec{\nabla} \times \vec{E} = -\Delta \vec{B} / \Delta t \\ \vec{\nabla} \cdot \vec{B} = 0 \\ \vec{\nabla} \times \vec{B} = \Delta \vec{q} / \Delta t + \Delta \vec{E} / \Delta t \end{bmatrix}$$

Appendix G: Anton Zeilinger's (*Dance of the Photons*) develops a translation of Bell's inequality for non-physicists:

$$\begin{bmatrix} \text{Number of pairs of twins} \\ \text{where one is tall and} \\ \text{the other has blue eyes} \end{bmatrix} \leq \begin{bmatrix} \text{Number of pairs of twins} \\ \text{where one is tall and the} \\ \text{other has brunet hair} \end{bmatrix} + \begin{bmatrix} \text{Number of pairs of twins} \\ \text{where one has blond hair} \\ \text{and the other has blue eyes} \end{bmatrix}$$

Appendix H: **How long can this go on?** AT&T analyzed 'bugs' in software: Many bugs are first found in new software (the model) but as the search continues time between bugs grows exponentially—providing an estimate of the bugs remaining and hence the validity of the model. And the longer colliders run without finding the postulated particles, the less likely that the current models are valid.

Appendix I: QED's vaunted 10 place accuracy is now 1 place accuracy: *the QED proton radius is off by 4% and vacuum energy is off by* 10^{120}. These facts are more serious than most physicists have yet realized. And QED requires a Higgs field, still not seen.

Appendix J: Abbreviations of common terms:

CMB – Cosmic Microwave Background
GEM – Gravito Electro Magnetics
LHC – Large Hadron Collider CERN
QCD – Quantum Chromodynamics
QM – Quantum Mechanics
SUSY – SuperSymmetry
FLRW – Friedericson, LeMaitre, Robertson, Walker
GR – General Relativity
QFT – Quantum Field Theory
QED – Quantum Electrodynamics
SM – Standard Model of Particle Physics