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Dynamic Modeling and the New Mathematics and Physics

E. E. Escultura

Institute for Advanced Studies, Department of Mathematics and Department of Physics
GVP College of Engineering, Madurawada, Visakhapatnam 530 041, A. P. India
E-mail: escultur36@yahoo.com, URL: http://home.iprimus.com.au/pidro/

Abstract: Catalyzed by unsolved scientific problems the paper examines the reach and limits of measurement, computation and mathematical modeling. Although physics gives the radius and radial rate of expansion and acceleration of our universe, detected the quarks and measured the electron's mass, unsolved problems remain, e.g., the gravitational n-body problem and basic constituent of matter, due to limitation of mathematical modeling that describes nature mathematically. Remedy: dynamic modeling that explains nature in terms of its laws. Moreover, some ambiguity of the real number system limits computation. Remedy: qualitative mathematics and upgrading of the real numbers system.

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1. INTRODUCTION

Some computations of mathematical physics are based on mathematical principles alone, others on the new physics (Grand Unified Theory or GUT). The crucial factor: dynamic modeling that explains nature in terms of its laws and overcomes weakness of mathematical modeling that describes nature mathematically. We summarize the critique-rectification of the underlying fields of Fermat's last theorem (FLT) – foundations and the real number system **R** (*reals*) – that yields the new real number system (new *reals*), **R***, +, ×, its extension to the new nonstandard analysis and counterexamples to FLT. Conventional modeling relies on measurement and computation, dynamic modeling on qualitative mathematics, complement of computation that includes abstract mathematical spaces, foundations and search for natural laws. The latter uses unsolved problems, e.g., FLT and the gravitational n-body problem, to advance mathematics and physics.

2. SOME UNSOLVED PROBLEMS OF PHYSICS

The most famous unsolved problem of physics is the gravitational n-body problem (Laplace, 1796).

Given n bodies, b_1, b_2, ..., b_n, at time T, masses, m_1, m_2 ..., m_n, at points, x_1, x_2 ..., x_n, and velocities, v_1, v_2 ..., v_n, subject to their mutual gravitational attraction, find their positions, velocities and paths at later time t. Unsolved for 200 years, it is vague, *mass* and *gravity* ill-defined and the basic constituent of matter unknown. Newton's gravitation

law describes attraction between masses m_1, m_2 grams s cm apart ($f = Gm_1m_2/s^2$, G cosmological constant [7]). With mass ill-defined, physical concepts are ambiguous and natural phenomena unexplained, e.g., electron, black hole and spin of galaxies, stars and planets.

3. THE REACH AND LIMIT OF MEASUREMENT AND COMPUTION

Despite limitation of mathematical modelling, physics made big strides in description of nature. The space telescope Hubble yields facts about our universe, e.g., radius: 10^{10} light years [8], its core, tightly packed cocoon shaped galaxy cluster 650 million light years across discovered by French astronomers in 1994. Hubble's law says, rate of separation between two galaxies at distance S (along great circle) is:

$$dS/dt = \rho S, \tag{1}$$

$\rho = (2.3)10^{-15}$ km/sec. GUT says: our universe is a super...super galaxy; outward flight of galaxies due to difference between centrifugal force and gravity. Since rate is independent of distance, take r = S; then,

$$\begin{aligned} &dS/dt = 2\pi dr/dt \text{ or} \\ &dr/dt = 2\pi\rho r \text{ or} \\ &dr/r = 2\pi\rho. \end{aligned} \tag{2}$$

Solving (2), differentiating, taking light year as unit of distance and 1 billion years as unit of time,

$$\begin{aligned} &r(t) = 10^{10}e^{(2\pi\rho)(t-12)} \text{ ly}, \\ &r'(t) = 2\pi\rho 10^{10}e^{2\pi\rho(t-12)} \text{ ly/by}, \\ &r''(t) = (2\pi\rho)^2 10^{10}e^{2\pi\rho(t-12)} \text{ ly/byby}. \end{aligned} \tag{3}$$

Converting to standard units we have,

$$r' = (6.28)10^5 \text{ km/sec}$$

and

$$r'' = (1.7)10^{-9} \text{ km/secsec}, \tag{4}$$

the rates of radial expansion and acceleration. Since $r'' > 0$, our universe is on the young phase of its cycle.

However, measurement is limited. We cannot detect objects smaller than the finest wavelength of light. Moreover, almost all differential equations are unsolvable since if $dy/dx = f(x)$ is solvable then $dy/dx = f(x)\sin 1/x$ is unsolvable at $x = 0$ [3,4]. Furthermore, the real numbers have ambiguity and inadequacy.

4. THE SOLUTION OF THE GRAVITATIONAL N-BODY PROBLEM

Laplace posed the gravitational n-body problem to establish stability of the solar system (our universe then). Therefore, the boundary conditions belong to the past, the solar system a solution. Hadamard called it ill-posed or inverse problem. The initial 11 laws of nature discovered in 1996 pinned down the basic constituent of matter (superstring),

explained gravity and anchored GUT [2]. Determination of trajectories required L. C. Young's integrated Pontrjagin maximum principle applied to generalized curves [12,13] but fractal reverse-fractal locator of GUT determined positions of the n bodies [5]. The problem is formulated as optimal control problem, target: boundary of smooth manifold, a half-sphere M (full solution in [2]).

The integrated Pontrjagin Maximum Principle. Let G be convex family of functions g(t,x), where $x \in \mathbf{R}^n$, let h be the corresponding Hamiltonian function yg(t,x), and let C be an M-extremal of the form x(t), $t_1 \leq t \leq t_2$, satisfying, a.e., the corresponding differential equation $dx/dt = \partial h/\partial y$; let C be subject to the conditions in [13], then there exists a conjugate vector y(t) along C such that the pair (x(t),y(t)) satisfies:

(a) The canonical Euler equations: $dx/dy = \partial h/\partial y$, $dy/dt = -\partial h/\partial x$;
(b) The Weierstrass condition: as function of $h \in H$: the integral $\int h(t,x(t),y(t))dt$, from t_1 to t_2, attains its minimum when $h = h$;
(c) The transversality condition: transversality vector $(-\eta(t_1),\eta(t_2))$ is inward normal of M at target.

This is a crowning triumph of standard mathematics; it is pure but has major applications to physics. For example, in sending rocket to the Moon, the transversality condition requires the terminal point of the optimal trajectory to be normal to the target, the lunar surface: steer lunar craft to, say, six feet above surface and drop it on the target (full trajectory is mixture of controlled trajectories).

5. RAPID AND WILD OSCILLATION

Rapid oscillation has form $y = f(x) = \beta(\sin n\pi x)(\cos^m k\pi x)$, where n, k, m are integers, $n >> k$, m even and $x \in [-1/k, 1/k]$. The function $\sin n\pi x$ mathematically models the photon as rapid oscillation $g(x) = \sin n\pi x$ inside the envelope, $h(x) = \beta\cos^m k\pi x$. The Planck's constant h is the energy of an arc of the photon; once the latter is known we can compute the number of full sinusoidal arcs the photon has.

The function $y = \sin^n(1/x)\cos^m(1/x)$, where m, n are integers is wild oscillation and set-valued at the origin. However, the parametric function,

$$\lim(\sin^n(1/(x-s))\cos^m(1/(x-s))), \text{ as } s \to 0^+,$$

is set-valued in the interval [0,1]. The case where m, n is even is the basis of the generalized integral of set-valued function with probability or unit measure distribution. The projection of P on the y-axis or any vertical axis at x oscillates between 0 and 1. The probability distribution is a mathematical model of the Heisenberg uncertainty principle. Consider the projection of the point P(x,y) on the wild oscillation $y = \sin^n(1/x)\cos^m(1/x)$ at the origin. It oscillates along the vertical axis at the origin, [0,1]. Cover the integral by non-overlapping subsegments {[y,y+dy)}, where at the lower end y = 0 and at the upper end dy = 0, the subsegment reducing to [y,1]. According to this principle, the faster the particle crosses a small interval the less is the probability that the particle is in it. In this model we represent the probability that the projection of P is not in a subsegment by the derivative and when suitably normalized we denote it by dp/dy. Denoting by dq/dy the probability that the projection of P lies in the subsegment then, suitably normalized, we have dp/dy + dq/dy = 1. The expectation is given by $\int_{[0,1]} y dp/dx$. This is a generalized

integral of set valued function. The probability distribution can be density or pressure distribution so that the generalized integral has physical applications. (For details and various cases see [3,4])

6. GENERALIZED FRACTAL

Generalized fractal extends self-similar transformations of contraction and translation (affine transformation) of ordinary fractal to include rotation, mirror-imaging about a line and sliding along a curve by qualitative mathematics alone. Nested fractal construction involves generating sequence of figures every term of which except the first is similar to and contained in the preceding term and, hence, similar to the first term. Contraction of figure involves pushing through its projection cone towards its vertex (at the origin). Construction of Peano space-filling curve (difficult by conventional methods) as set limit of generalized fractal shows power of qualitative mathematics. Here, the aim is to map the unit interval [0,1] continuously onto the unit square S with vertices A(0,0), B(1,0), C(1,1), D(0,1).

Divide the unit square into 9 little squares by lines x = 1/3, x = 2/3, y = 1/3, y =/2/3; denote them by, S_{11}, S_{12}, S_{13}, S_{21}, S_{22}, S_{23}, S_{31}, S_{32}, S_{33}, starting at A(0,0) of S_{11}, going right, up, left, up, right and ending at C(1,1) of S_{33}. Let $g_{1,1}$: $y = x$, $0 \leq x \leq 1/3$; $g_{-1,1}$: $y = -x$, $0 \leq x \leq 1/3$; $g_{-1,-1}$: $y = x$, $0 \geq x \geq -1/3$; $g_{1,-1}$: $y = -x$, $0 \leq x \leq 1/3$. The $g_{i,j}$s are initial generators of first term f_1 of fractal sequence we are constructing obtained by suitable translations to diagonals of S_{mn}s forming homotopic image of the unit interval [0,1], a directed polygonal line in same order as S_{mn}s, initial point at A(0,0) and terminal point at C(1,1). The initial function f_1 consisting of polygonal lines through diagonals of S_{mn}s and the next term f_2, generated similarly, are:

$f_1(t)$: $g_{11}(t)$, $g_{1-1}(t)$, + (1/3.1/3), $g_{11}(t)$ + (2/3), $g_{-11}(t)$ + (1,1/3), $g_{-1-1}(t)$ + (2/3,2/3), $g_{-11}(t)$ + (1/3,1/3), $g_{11}(t)$ + (0,2/3), $g_{1-1}(t)$ + (1/3,1), $g_{11}(t)$ + (2/3,2/3), $0 \leq t \leq 1/3$. (5)

$f_2(t)$: $g_{22}(t)$, $g_{2-2}(t)$ + (1/3,1/3), $g_{22}(t)$ + (2/3,0), $g_{-22}(t)$ +(1.1/3), $g_{22}(t)$ + (2/3,0), $g_{-2-2}(t)$ + (2/3,2/3), $g_{-22}(t)$ + (1/3,1/3), $g_{22}(t)$ + (2/3,2/3), $g_{2-2}(t)$ + (1/3,1), $g_{22}(t)$ + (2/3,2/3), $0 \leq t \leq 1/3$. (6)

Contract S to little square with vertices A(0,0), B_1(1/3,0), C_1 (1/3,1/3). Call this $g_{2,2}$, a fractal generator of second term f_2 of the fractal sequence. Find its mirror-image about y-axis, that of latter about –x-axis and last one about –y-axis to find other generators: $g_{-2,2}$, $g_{-2,-2}$, $g_{2,-,2}$. Now restore S and subdivide again into 9 little squares by lines x = 1/3, x = 2/3, y = 1/3 and y = 2/3. As in f_1, translate generators suitably into little squares in same order to find finer polygonal line, homotopic image of interval [0,1], initial point A(0,0) and terminal point C(1,1). Contract again into little square, vertices at A(0,0), B_1(1/3,0), C_1 (1/3,1/3), and do the same mirror-imaging, to find fractal generators, suitable translations to find f_3, and contraction, etc. Then the uniformly convergent sequence of continuous functions, f_1, f_2, f_3, ..., converges to continuous function, the Peano-space-filling curve, set limit of the fractal sequence, f_1, f_2, f_3, ... (graphics in [4]).

7. FOUNDATIONAL REQUIREMENTS OF DYNAMIC MODELLING

Dynamic modelling requires unambiguous contradiction-free mathematical base space. Critique-rectification of underlying fields of FLT, foundations, number theory and the

reals, insures that base: the new *reals* and its extension, the new non-standard analysis [9]. The foundational requirements are:

1) The concepts of individual thought cannot be the objects or subject matter of a mathematical space since they are inaccessible to others and can neither be studied collectively nor axiomatized.
2) Therefore, a mathematical space must consist of symbols (we also call them concepts) well-defined by consistent axioms; a concept is well-defined if its existence, properties and relationship with other concepts is specified by the axioms; for a decimal: every digit is known or computable.
4) It follows from 1) and 2) that the rules of inference are specific to and specified by the axioms.
5) The sources of ambiguity, aside from ill-defined concepts, are: small and large numbers (depending on context) due to limitation of computation, infinite set (more precisely, finite but unbounded), vacuous concept and proposition and self-reference; in particular, the indirect proof.
6) To avoid ambiguity a mathematical space must be built initially on finite set. Then ambiguity may be introduced provided it is "approximable" by certainty; for example, a well-defined nonterminating decimal is approximated by its initial segment at nth digit and at margin of error 10^{-n} [6,9].
7) Since two distinct mathematical spaces are independent a concept in one is ill-defined in the other.
8) Therefore, a proposition is ill-defined, ambiguous and undecidable if it involves concepts from two distinct mathematical spaces (basis of characterization of undecidable propositions).
9) Axiom cannot be ambiguous; proposition about infinite set involving existential or universal quantifier is ambiguous and unverifiable, therefore, inadmissible as axiom.
(10) For now, the continuum is ill-defined, however, the new *reals* will be shown to be a continuum but the decimals remain countably infinite, hence discrete, being the countable union of countable sets.

8. WEAKNESS OF THE REAL NUMBER SYSTEM

Below are problems with the *reals* **R** from which follows that it is ill-defined.

i) The trichotomy axiom is false, a counterexample to it constructed by Brouwer [1].
ii) Completeness axiom: inadmissible, involves universal and existential quantifiers on infinite set.
iii) Addition and multiplication are ill-defined on nonterminating decimals.

9. THE NEW REAL NUMBER SYSTEM

The new *reals* $\mathbf{R}^*$, +, × consists of decimals well-defined by these axioms: a) $\mathbf{R}^*$ contains the basic integers, 0, 1, ..., 9, and b) addition and c) multiplication tables of ordinary arithmetic that well-define only terminating decimals and their relationship. For now only terminating decimals are well-defined by the addition and multiplication tables; irrationals inherently uncertain but approximable by certainty.

Although the tables well define only a few terminating decimal we enlarge them as follows:

$$a_k a_{k-1}\ldots a_1.b_n b_{n-1}\ldots b_1 = a_k 10^k + a_{k-1}10^{k-1} + \ldots + a_1 + b_n/10 + b_{n-1}/10^2 \ldots + b_1/10^n, \quad (7)$$

where the a_i's and b_j's are basic integers and $a_k a_{k-1}\ldots a_1$ and $b_n b_{n-1}\ldots b_1$ are their integral and decimal parts, respectively. A nonterminating decimal is the Cauchy limit of its standard Cauchy sequence:

$$N.a_1a_2\ldots a_n\ldots = N.a_1, N.a_1a_2, \ldots, N.a_1a_2\ldots a_n, \ldots, \quad (8)$$

where each a_n is known or computable. Every term of standard Cauchy sequence reproduces preceding digits; it remains standard Cauchy sequence of same number when finite segment is deleted. Therefore, we define nonterminating decimal as Cauchy limit of the equivalence class of its Cauchy sequences.

Elements of new arithmetic: the integers, new integers N.99..., N = 0, 1,..., is integer, dark number d* = 1 − 0.99..., nonterminating periodic and nonterminating nonperiodic (irrationals), unbounded number u*; d* and u* are nonstandard new *reals*, u* is the equivalence class of divergent sequences; d* is Cauchy limit of equivalence class of its nonstandard Cauchy sequences; its principal Cauchy sequence is: 0.1, 0.01, ..., $(0.1)^n$, ... where n = 1, 2, ... are positive integers; d* and u* are not decimal.

The mapping, $0 \to d^*$, $N \to (N-1).99\ldots$, is an isomorphism between the integers and new integers which implies similarity of properties with respect to addition and multiplication. Moreover, the mapping $N \to N.00\ldots$ embeds the integers isomorphically into the integral parts of the decimals subject to the axioms of the new *reals*. This rectifies the fundamental defect of number theory: its subject matter, the integers, are ill-defined. Furthermore, the mapping $N.b_n b_{n-1}\ldots b_1 \to N.b_n b_{n-1}\ldots b_1 00\ldots$ embeds the *reals* isomorphically into the new *real* so that the well-defined *reals* are retained in the new *reals*. More properties of $\mathbf{R}^*$:

1) Decimals of the form, $x = N.a_1\ldots a_n 00\ldots$ and $y = N.a_1\ldots b_n 99\ldots$, e.g., 4.3700... and 4.3699..., differ by d*; they are called adjacent decimals; since no decimal can be inserted between them d* is a continuum. Therefore, since d* joins adjacent decimals, its union with the decimals, i.e., $\mathbf{R}^*$, is a continuum.
2) The Cauchy limit of a decimal (as standard Cauchy sequence) is adjacent to its limit point, e.g., Cauchy limit of 0.9, 0;99, ..., 0.99. . .9 is 0.99... its limit point is 1.
3) The new arithmetic (computational component of the new *reals*) has the following properties:
   $(0.99\ldots)^n = 0.99\ldots$, n = 1, 2, ...; $(d^*)^n = d^*$; $x(0.99\ldots)^n = x$; $xd^* = d^*$; $xu^* = u^*$; $1/d^* = u^*$; $1/u^* = d^*$; if x is not a new integer, $x + d^* = x$; $x + u^* = u^*$; $d^* - d^*$, d^*/d^*, u^*/u^*, $u^* - u^*$ are indeterminate. Cauchy convergence induces the Cauchy metric $d = \text{Clim} \left| C_n - K_n \right|$, C_n, K_n, their respective Cauchy nth terms.
4) A nonterminating decimal is approximated by its nth Cauchy terms at margin of error 10^{-n} and computation involves approximation by the nth terms (nth decimal segments in the *reals*).
(5) The decimals are countably infinite and, therefore, discrete, have natural ordering (the *reals* have none), consistent, Archimedean and Hausdorff but its union with d* and u*, i.e, $\mathbf{R}^*$, is a continuum, non-Archimedean and non-Hausdorff. $\mathbf{R}^*$ Extended to include additive and multiplicative inverses $\mathbf{R}^*$ forms a complete (in Cauchy norm), ordered, semi-field (not all nonzero decimals have multiplicative

inverses). It serves as base space of new nonstandard analysis, appropriate for physics and computing.

10. ADVANTAGES OF R* AND THE CAUCHY NORM

(1) **R*** retains the well-defined decimals and their properties. Moreover, the Cauchy norm: (a) avoids indeterminate forms, (b) gives result of computation directly as terminating or nonterminating decimal digit by digit, (c) tames eliminates the chaos in **R** and (d) calculates the limit point which is adjacent to the Cauchy limit (differs by d*); in particular, the standard norm of a *real* is adjacent to its Cauchy norm.

(2) The new axiomatization provides the conditions for advancement and new discoveries,

(3) Raises the capability of mathematics to resolve mathematical and scientific problems, especially, the long-standing ones, and opens up new research opportunities.

Open problems: (1) What is the continuum's cardinality if any? (2) Does nondenumerable set exist? If it does, prove or construct it?

Conjecture: The only set with cardinality is discrete.

11. UNEXPLAINED PHENOMENA

Among the previously unexplained phenomena explained by GUT [7] are: wave, ordinary and cosmic; primal polarity; biological organism; photon and wave-particle duality; matter-anti-matter interaction; genesis of the atom, its nucleus and formation of heavy isotope; superconductivity; Brownian movement; brittle and malleable materials and elasticity; heat, fire and their propagation; the Colombia disastrous flight puzzles; metal fatigue; thermonuclear reaction; guidance of migratory birds; macro and quantum gravity; black hole; Big Bang; Cosmic Sphere and Cosmic Burst; genesis and formation of visible matter in cosmological bodies; rapid and accelerated expansion of our universe; debris in the Cosmos; supernova; Earthlights and balls of fire; solution of the turbulence problem including typhoon and tornado; earthquake, tsunami, tidal action and eclipse; transitory nature of natural laws; dimension; cosmology of our universe; mathematical model of the Universe and our universe; and the new technology. Some are explained below.

12. THE LAWS OF NATURE

We start with the most fundamental law of nature, first law of thermodynamics, and find others consistent with it. However, it is inadequate: some natural phenomena appear to contradict it; e.g., when beam of light in vacuum is turned off it vanishes without trace. Therefore, we generalize and embellish it with other components as stated below to broaden validity. Energy is motion of matter; therefore, matter and energy cannot be separated. We have yet to know what matter is. Light is kinetic energy, that is, visible motion of matter. We introduce the concept latent or dark energy that is not directly observable but convertible to visible or kinetic energy. Then we state the most fundamental law of nature.

Natural Law I (Energy Conservation). *In any physical system and its interactions, the sum of kinetic and latent energy is constant, gain of energy is maximal and loss of energy minimal.*

With spectroscopy we look into the immediate and distant past and study the Cosmos with light as medium. Only object of the same order of magnitude as the finest wavelength of visible light, 10^{-14} meters, is observable (principle of resonance).

The Hubble reveals matter forms steadily in supposedly empty Cosmos at rate of one star per minute [11]. A nascent galaxy was discovered recently. How do we reconcile these with energy conservation?

Natural Law II (Existence of Two Fundamental States of Matter). *There exist two fundamental states of matter: visible and dark; the former is directly observable and the latter is not.*

Dark matter is verified by impact on visible matter, e.g., star formation. With existence of dark matter, we now ask: what does it consist of? The answer – the superstring – resolves the 5,000-year-old quest for the basic constituent of matter. It would take more laws of nature to provide the right structure to it and another law that converts it to unit of visible matter called the primum [7,8].

Natural Law III (Flux-Low-Pressure Complementarity). *Low pressure sucks matter around it and the initial chaotic rush of dark matter towards low pressure stabilizes into local or global coherent flux; conversely, coherent flux induces low pressure around it.*

This law explains formation of earthly vortices, e.g., typhoon and tornado.

Natural Law IV (Energy Conservation Equivalence). *Energy conservation has other forms: order, symmetry, economy, least action, optimality, efficiency, stability, self-similarity (fractal), coherence, resonance, quantization, smoothness, uniformity, motion-symmetry balance, non-redundancy, evolution to infinitesimal configuration, helical and related configuration such as circular, helical, spiral and sinusoidal and, in biology, genetic encoding of characteristics, reproduction and order in diversity and complexity of functions, configuration and capability.*

Non-redundancy means nature does not create another physical system with the same functions. The so-called third quark in the nucleus of an atom outside the proton discovered in 2004 does the same function as the negative quark in the proton – joins its two positive quarks. The third quark also joins two positive quarks, one from each of two protons. Therefore, it must be the same negative quark. One negative quark serves as connector between two positive quarks of the same proton and the other as connector between two positive quarks of different protons. Note that qualitative mathematics and the natural laws solve problems inaccessible to computation, e.g. determining structure of the superstring, primum, etc.

We summarize how the superstring is built using the natural laws. Its existence is assured by Natural Law II. Dark matter is made up of superstrings at various phases of their cycles from non-agitated through semi-agitated, agitated and back to non-agitated as black hole.

Natural law V (The Basic Constituent of Matter and its Structure). *The basic constituent of dark matter is the superstring. It is a loop and nested fractal sequence of superstrings or toroidal fluxes, with itself as the first term; each toroidal flux in the sequence is a superstring having toroidal flux, a superstring, traveling at speed beyond that of light along its cycles, etc.; each superstring except the first, is contained in and self-similar to the preceding term in structure, behavior and properties.*

Natural Law VI (Semi-agitated Superstring Formation). *When suitable cosmic wave hits (agitates) a non-agitated superstring one of the following occurs: (a) its first term as*

nested fractal sequence expands and becomes a semi-agitated superstring with the rest of the sequence as its toroidal flux; (b) it is projected into the first term of a new superstring with itself as the toroidal flux or simply loses the energy imparted by the cosmic wave and remains dark.

Dark matter consists of superstrings that fill up the Universe; by Natural Law III, which is unbounded. Superstring is dark if cycle length is less than 10^{-14} meters, visible, and semi-agitated if a segment has cycle length between 10^{-16} and 10^{-14} meters and non-agitated if cycle length is less than 10^{-16} meters. By energy conservation a superstring shrinks steadily, the reason it is modeled by dark number [6]. Dynamic modeling imparts needed structure to superstring to do its task: explain natural phenomena.

Natural Law VII (Dark-to-Visible-Matter Conversion). *When suitable shock wave hits a semi-agitated superstring one of these occurs: (a) the outer superstring breaks, its flux torus remaining non-agitated superstring; (b) a segment bulges to form a primum, unit of visible matter.*

By energy conservation equivalence configuration of a primum is obtained by rotating full arc of sinusoidal curve of even power about its axis joining both end points. Graphics of prima, basic cosmic waves and cosmic waves of types I, II and III are found in [4]. Induced primal flux of a primum is visible and measured as charge. Moving charge is electricity. Since the toroidal flux of primum hit by comic waves from all directions is thrown into erratic motion called *spike* in its infinitesimal neighborhood, it pulls the superstrings around into a vortex flux of superstrings detected as charge. Moroever, when a primum is scooped up by basic cosmic wave and breaks away from its loop as photon (rapid oscillation of its flux torus) its forward speed equals the speed of light, implying that its toroidal flux speed is greater than the speed of light. The induced vortex flux forms a magnetic field aligned by the Earth's gravitational flux [7]. Using the right-hand rule a primum has positive charge if its induced flux, viewed from its north pole, is counterclockwise, negative otherwise. The electron's charge of -1 is the unit of charge. Other basic simple prima are: positive quark, charge $+2/3$; negative quark, charge $-1/3$ [10]. By flux compatibility, positive light go up into the atmosphere, possibly into the mesosphere or even byeond; heavy prima and free ions go up into the lower atmosphere; prima and ions go down to the ground [7].

Natural law VIII (Flux Compatibility). *Two prima of opposite flux spins attract each other at their equators but repel at their poles; prima of same flux spin repel at their equators but attract at their poles. Two prima of same spin connect equatorially only through a primum of opposite flux spin between them.*

The neutrino is a neutral primum; therefore, it must be equatorially coupled pair of prima of equal but opposite charges, their sum is 0 and there is no net charge around it.

The proton is a pair of positive quarks joined together equatorially by a negative quark as connector so that its charge is: $+2/3\ -1/3\ +2/3 = +1$. Thus, the proton has counterclockwise net induced flux, the negative quark an eddy in it. Energy conservation requires the axis of its component quarks to be collinear.

The proton, electron and neutrino comprise the neutron. The electron may attach itself to positive quarks by flux compatibility, but energy conservation requires it attaches between the two positive quarks of proton beside negative quark. Flux compatibility pushes negative quark a bit so centers of all four quarks form a quadrilateral. The four coherent fluxes around its center makes middle low pressure region that sucks matter around it. It cannot suck charged primum since it is repelled by positive or negative prima already there. Therefore, the only primum that fits is light and neutral neutrino. Thus, the neutron's charge is: $+2/3\ -1/3\ +2/3\ -1\ +\ 0 = 0$; it has no net flux around it. Since the

neutron's mass and combined mass of proton and electron [10] are, respectively, 1.0087 and $1.0073 + 5.4860 \times 10^{-4}$ amu, we take their difference and find the mass of the neutrino: $\eta = 8.5 \times 10^{-4}$ amu or 1.55 times electron's mass.

Natural Law IX (Internal-External Factor Dichotomy). *The interactions and dynamics of a physical system are shaped by the internal and external factors; in general the internal is principal over the external and the latter works through the former.*

Principle X (Law of Uneven Development). *In any process or interaction development proceeds unevenly and perfect balance and uniformity is unstable.*

This explains why planetary orbit is elliptical: the uneven, fluctuating and oscillatory balance between gravity and centrifugal force along the radius.

13. EXPLANATION OF SOME NATURAL PHENOMENA

(1) **Primal polarity.** Since semi- and non-agitated superstring has infinitesimal induced flux it has no interaction and is randomly oriented; this makes dark matter completely stable. The polarity of a primum is determined by the angle of its axis relative to the Earth's gravitational flux that aligns it when it pops out of dark matter and makes its induced vortex flux an eddy, its axis normal to it in either direction (energy conservation), i.e., positive or negative. By flux compatibility positive primum is pushed upwards by Earth's gravitational flux way up into the upper atmosphere. We expect abundance of positive prima. Positive ions, being heavy, although similarly oriented as eddy in the Earth's gravitational flux, remain in the lower atmosphere. The electron as clockwise eddy in Earth's gravitational flux is pushed downwards, by flux compatibility. Thus, there is abundance of electrons on the ground. When the voltage between the electrons and positive ions reaches critical level they clash and explode as lightning. Other negative prima are the negative quarks which are abundant on the ground also, free or unfree. [7]

(2) **Genesis of the atom and formation of heavy isotope.** The first thing that forms in an atom is the nucleus consisting of protons alone. How many protons stick together, depends on the initial conditions. For instance, in the early hot universe only the lightest hydrogen atom with one proton forms. Today the cooler planets like Earth allow formation of complex atoms like beryllium. The massive planets like Jupiter have powerful vortices and, therefore, hot cores that allow only light and simple atoms like gases to form. Given the right conditions protons are joined by negative quarks to form the initial nucleus, their number stochastically determined. Their fluxes form a vortex positively oriented by the protons; the nucleus remains in its cylindrical eye. The eye sucks neutral primum since charged primum is repelled by either positive or negative quark. It sucks neutron to form heavy isotope. The suction energy that holds and keeps them in the eye is proportional to the number of protons in the nucleus. The periodic table shows the nucleus holding slightly more neutrons than protons. The neutrino may be sucked also but it simply whizzes by at great speed. Suction steadily accumulates dark superstrings in the nucleus. They convert to kinetic energy (prima and radiation) in nuclear fission. Electrons are attracted by the atomic flux, by flux-low-pressure complementarity and flux compatibility, but being too light they are swept into orbit. [7]

(3) **Genesis of and populating a galaxy with visible matter.** Steady shrinking of superstrings combined with the law of uneven development gives rise to nested fractal sequences of low pressure which, by flux-low-pressure complementarity, form nested fractal sequences of cosmological vortices in dark matter. Galaxies form this way including our universe (a super...super galaxy). Once cosmological vortex forms its

core's spin builds up kinetic energy as matter falls into and spins around the eye. The micro component of turbulence (at the spinning superstrings around the eye) generates seismic waves that convert dark matter to prima. They get entangled into nested fractal sequences of minor vortices down to micro vortices that collect cosmic dust that gets entangled with them and congeal into galaxies, stars, planets, moons and cosmic dust. [7]. A piece of cosmic dust is collected mass at core of micro cosmological vortex.

(4) **The Big Bang.** A black hole is concentration of non-agitated superstrings collected in the eye of cosmological vortex. The Big Bang was an explosion of black hole, the destiny of the core of a previous universe, some 12 billion years ago. The explosion pushed dark matter away against the inward pressure of dark matter forming the Cosmic Sphere that accelerated outward. The explosion caused a super...super depression in its interior. The most energetic shock waves pierced the Cosmic Sphere and began to convert dark to visible matter outside. The less energetic ones bounced back and forth between the outer and inner boundaries of the Cosmic Sphere agitating the trapped and compressed superstrings and turning them into semi-agitated superstrings. As it expanded the Cosmic Sphere weakened and burst at t = 1.5 billion years after the initial explosion. This is called the Second Big Bang and may be considered the terminal phase of the Big Bang. The semi-agitated superstrings scattered around the Cosmic Sphere and converted to prima and photons. They were the initial visible matter of our universe called quasars as it evolved into the super...super galaxy, our universe, by flux-low-pressure complementarity. [7]

(5) **Supernova.** The current understanding of supernova as explosion of star is incorrect since cosmological vortices are stable. Left alone, a star evolves towards higher order, a black hole in its eye. Therefore, its only plausible explanation is collision of two stars of opposite spins in their common equatorial plane. If they have the same spin they avoid each other, by flux compatibility. With opposite spins they attract each other and, by their momentum, their fluxes between their eyes merge smoothly at first until the rim of one goes past the eye of the other and their fluxes there, being opposite, collide resulting in double explosion. Then the flux barrier between their eyes breaks and causes huge depression that violently sucks matter around causing more powerful third explosion. Photographs of supernova show the three rings of visible matter on expanding shock waves. Supernova is quite rare since stars are sparse.

(6) **Transitory nature of natural laws.** Natural phenomena (visible physical systems) reveal natural laws. Before the Big Bang there was no natural phenomenon in our part of the Universe and no natural laws they revealed. After the Cosmic Burst, natural phenomena appeared with increasing complexity. Naturally, they reveal new laws of nature. Now there are new phenomena and natural laws that did not exist in our young universe, e.g., biological phenomena and laws governing them. The latter will become empty as natural phenomena vanish and our universe reaches its destiny as black holes back in dark matter. [7]

(7) **Cosmology of our universe.** Matter collects around the eye of cosmological vortex. As its vortex flux thins out the collected mass gets isolated and its spin and kinetic energy decline. Its inner boundary de-agitates and forms the superstrings into black hole inside until the latter becomes naked with the thinning of the gravitational flux. All cosmological bodies share this destiny and our universe, a super...super galaxy will eventually become cluster of black holes. There is evidence of weakening of the Earth's magnetic field which may indicate that our planet is on the downturn of its power of spin as cosmological vortex. [7] $\mathbf{R}^* \times \mathbf{R}^* \times \mathbf{R}^*$ models the timeless unbounded physical Universe, $\mathbf{R}^*$ physical time and distance, non-standard Cauchy sequence of d^* the nested

fractal superstring and d* the tail end of its toroidal fluxes: a superstring and continuum. The decimals model the metric system and the integers the countably infinite and discrete dark matter. Our universe is finite, so are its superstrings and visible matter.

(8) **Dynamic Modelling.** GUT dynamically models our universe.

(9) **A paradox no more.** Originally referring to our universe, Olber's paradox says that it can't be infinite, otherwise, accumulated light coming from all directions would have fried us in intense light by now which has not happened In fact, the average temperature of our universe is 4° C despite the fact that stars alone form at the rate of one per minute plus the formation of at least one galaxy discovered recently. This is offset by the rapid expansion of our universe. This paradox is, of course, moot since our universe is finite. However, we can extend this issue to the unbounded Universe. Can visible matter be infinite? Since dark matter is unbounded there is no reason to rule out unbounded visible matter. There are two possibilities regarding accumulation of light. a) Visible matter is suitably dispersed that light reaching our universe does not accumulate or b) light reaching our universe is deflected by its gravitational flux (in the same way that asteroids missing the narrow injection angle are deflected by the Earth's gravitational flux). Either case has no bearing on our universe's temperature or its distribution.

Finally, this positive note: the latent energy density of dark matter is 10^{26} joules/ft^3 [7,8,10] which is convertible to clean useful energy such as electricity that can avert the looming global energy crisis.

References

[1] Benacerraf, P. and Putnam, H. (1985) Philosophy of Mathematics, Cambridge U Press, Cambridge.

[2] Escultura, E. E. (1997) Flux theory of gravitation (FTG) I. The solution of the gravitational n-body problem, Nonlinear Analysis, **30**(8), 5021 – 5032.

[3] Escultura, E. E. (2000) FTG IX. Set-valued differential equations and applications to quantum gravity, Mathematical Research, Vol. 6, 2000, St. Petersburg, 58 – 69.

[4] Escultura, E. E. (2001) FTG X. From macro to quantum gravity, J. Problems of Nonlinear Analysis in Engineering Systems, **7**(1), 56 – 78.

[5] Escultura, E. E. (2001) FTG III: Vortex Interactions, J. Problems of Nonlinear Analysis in Engineering Systems, Vol. **7**(2), 30 – 44.

[6] Escultura, E. E. (2002) FTG V. The mathematics of the new physics, J. Applied Mathematics and Computations, **130**(1), 145 – 169.

[7] Escultura, E. E. FTG XXXV (2006) The Pillars of FTG and some updates, Nonlinear Analysis and Phenomena, **III**(2), 1 – 22.

[8] Escultura, E. E. (2005) FTG XXVI. Dynamic Modeling of Chaos and Turbulence, Nonlinear Analysis, **63**(5-7), e519 – e532.

[9] Escultura, E. E. (2005) FTG. XXVI. Introduction to the new nonstandard calculus, to appear, Nonlinear Analysis and Phenomena.

[10] Gerlovin, I. L. (1990) The Foundations of United Theory of Interactions in a Substance, Leningrad: Energoattomizdat

[11] Science, Glow reveals early star nurseries, **281**(5375), July 1998, 332 – 333.

[12] Young, L. C. (1937) Generalized curves and the existence of an attained absolute Minimum in the calculus of variations, Camp. Rend. Sac. Sci. Letter., Varsovie, Cl III, **30**, 211 – 234.

[13] Young, L. C. (1969) Lectures on the Calculus of Variations and Optimal Control Theory, W. B. Saunders, Philadelphia.