Unified Field Theory, Symmetry Breaking and the Emergence of Order

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In this paper, the author presents a conceptual model of a *unified field theory* that is based on group symmetry characteristics of matter -- i.e., on the 'charge' conserving and gauge-invariant properties of elementary particles and fields. In such a model, it will be shown that emergence of order and structure in physical, chemical and biological systems inevitably arises through a series of *bipolar* symmetry breaking phase transitions in an expanding universe.

The basic foundation of the proposed model is derived from recent developments in quantum field theory, e.g., super-symmetry group models, where the existence of higher quantum spin states and greater degrees of freedom in the space-time manifold is postulated. In the proposed unified field model, the origin of the physical universe is considered an *'ergodic'* phenomenon, i.e., a probabistically rare, but temporally-finite event. The cosmic 'big bang' is thus seen as arising from a thermodynamically unstable state of primordial matter in an extremely low entropic state in a localized region of the background vacuum (governed by a scalar potential), that led to a *hyper-inflationary expansion* of the emergent physical universe, as recently described by A. Linde.

While the overall entropy of the physical universe increased against the initial localized 'singularity' of the background vacuum, other localized low entropy states, with relatively stable structure and order, evolved through a *nested hierarchy* of symmetry breaking transitions. In addition, the stability of matter is maintained by the formation of gauge-invariant local symmetries -- i.e., through the 'partial' restoration of local symmetry fields in a globally symmetric field. It is postulated that through such *symmetry breaking and restoring processes*, the emergence of 'proto-galaxies' (containing dark matter) and the presently observable galaxies, stellar bodies and planetary objects have arisen. Similarly, it is proposed that chemical and biological evolution at the terrestrial level have proceeded through an analogous series of symmetry breaking and restoring processes, with increasing degrees of complexities and emergent order.

In the paper, a number of novel concepts are discussed that are based on the principles of an *axiomatic symmetry field theory*. These include:

- the concepts of resting *mass or inertia*, which are viewed as the measure of *relative resistance* encountered by locally *a*symmetric fields when they are spatially displaced with respect to a globally symmetric field. Such a dynamical concept of mass appears to be consistent with the conceptual foundations of Mach's principle,

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- the underlying nature of the *characteristic wave velocities* of each globally symmetric field. In the proposed model, for example, it is postulated that gravitational field waves travel at propagation velocities *greatly in excess* of electromagnetic field transmissions. Such a conclusion appears to extend, but not contradict the principles of special relativity,

- the existence of *dark matter particles and fields*, that exert weakly-coupled, but extremely long-ranged field effects that are *not* gravitational in origin. In such a scenario, it is postulated that all regions of the universe are *causally linked* by a finite dark matter field force that appear to be almost instantaneous,

- the possible existence of *parallel or multiple universes* that grew out of a series of thermodynamically unstable and low entropic regions of the primordial vacuum state of a 'super-universe',

- the emergent order and structure of *more complex chemical and biological systems*, that *are consistent with, but not reducible to* the symmetry breaking and restoring processes of physical systems.

I. INTRODUCTION:

In the past few decades, the incorporation of symmetry principles, based on mathematical concepts of group theory, has become one of the most important and fruitful means for building theoretical models of particles and fields in the physical sciences (Sternberg, 1994; Coleman, 1985; Wigner, 1979). Although extraordinary progress has been made in applying these symmetry group principles in developing a number of successful quantum field theories, their foundational basis with respect to dynamical properties of elementary particles and fields have remained elusive and is still not well understood at a conceptual level. Part of the reason for this deficiency has been the lack of clarity about why symmetry group principles work so outstandingly well in elementary particle and quantum field theories in the first place. This becomes even more apparent when we try to incorporate free-standing physical parameters, such as resting masses of elementary particles, in constructing relativistic quantum mechanical models. In this paper, the author will attempt to present a new and hopefully more coherent picture of dynamical properties of matter, that are based on fundamental symmetry and symmetry breaking principles. The overall objective is to apply these abstract symmetry principles to a proposed model of a unified field theory that attempts to describe the 'emergence' of ordered systems in an evolving physical, chemical and biological universe.

Since the 1950s, with the growing and widespread applications of continuous (or Lie algebra-based) group symmetry principles to physical models, a number of heuristic and renormalized models in quantum field theory have been constructed (Weinberg, 1996; Gross, 1993; Kaku, 1993; Pokorski, 1987; Ryder, 1985; Mandl and Shaw, 1984). These include the derivation of:

(i) a relativistic, Lorentz-invariant quantum electrodynamic model (*QED*), with a local group symmetry, *U(1)*;

(ii) a gauge-invariant electro-weak unified field theory based on a mixed local group symmetries, *SU(2) x U(1)*;

(iii) a gauge-invariant, color-based strong force field theory or quantum chromodynamics (*QCD*), based on a local group symmetry, *SU(3)*;

(iv) a more unified strong-electro-weak model based on mixed local group symmetries, *SU(3) x SU(2) x U(1)*, or alternatively, a grand unified theory model (*GUT*), with an elegantly simple and unmixed local group symmetry, *SU(5)*.

To the group symmetric models mentioned above, we should add the earlier Lorentz-invariant formulation of Einstein's theory of relativity, which reflected *global* (special relativity) and *local* (general relativity) group symmetries of electromagnetic and gravitational fields at the macroscopic (i.e., terrestrial and cosmological) levels of observations (Goldstein, 1980). Though not initially recognized as such, the concept of gauge-invariant, local group symmetries are implicitly present in the covariantly-derived field equations of general relativity. Thus, by keeping Lorentz invariance of special relativity intact at every local frame of reference, the mechanical and electrodynamic laws of physical systems remain globally covariant under all coordinate transformations.

More recently, even higher symmetries have been invoked that attempt to bring both non-integral spin fermions and integral spin bosons under one large gauge-invariant, local symmetry group, such as *SO(16)* or *SO(32)* (N = 1 to 8) (Salam, 1989, 1990; Pokorski, 1987). Since such *super-symmetry* models have sufficiently extensive degrees of freedom, they are able to accommodate all observed (and as yet unobserved) fermions and bosons under a single conceptual framework of the present Standard Model of elementary particles[1]. In other words, it puts on equal footing all three generations of fermionic particles (leptons and quarks) with their counterpart gauge-invariant bosons (photons, W and Z particles, gluons, etc.), that determine the existence of electromagnetic, strong and weak force fields in the physical universe.

At the present moment, however, a successful super-symmetric quantum field theory that unifies strong-weak-electromagnetic with gravitational fields has not been achieved. That is, we do not yet have a renormalizable *super-gravity* model (with gauge-invariant Yang-Mills fields), which incorporates spin(2) gravitons with other known spin(1) bosons and spin(1/2) fermions (Isham, 1989). For example, as a 'non-point particle' super-symmetric model, *super-string* theory had shown initial success in removing a number non-renormalizable factors and anomalies that had plagued earlier versions of super-gravity models (Green, et al., 1987). Inspite of its many methodological and technical achievements, a gauge-invariant super-string theory has yet to be formulated on firm conceptual grounds (Witten, 1997). Moreover, being intrinsically unable to make dynamical predictions at phenomenologically-relevant energy levels, it is unclear whether super-string theory could serve at present as the all-encompassing quantum field theory of all known elementary particles and fields.

In this paper, we shall avoid discussing the detailed features of the group symmetry properties of the quantum field models described above. Instead, we shall examine, at a preliminary and conceptual level, whether a more general and logically consistent presentation of global and local symmetry fields may be arrived at so that one could gain a better understanding of the underlying dynamical basis of quantum field models. From the outset we shall be making an *explicit* distinction between global and local (or gauge-invariant) symmetries of particles and fields. We shall show how kinematical and dynamical properties of matter (such as mass, momentum, force, energy, action, etc.) come into being once these symmetry principles are taken into account, especially when they are placed within a more comprehensive unified field theory. In addition to symmetry beaking principles, we shall be

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[1] Such a super-symmetric state may be achieved at enormously high energy levels, i.e., around 10^{15} GeV, or only three orders of magnitude below the so-called Planck energy scale of 10^{18} GeV.

introducing the concept of *restoration* of local (gauge-invariant) symmetries. It is postulated that *the interplay between the breaking and restoration of local symmetries, within the context of global symmetries, is the underlying physical process through which elementary particles and force fields arise*, which in turns allows for relatively stable matter to make their appearance in an emergent and evolving universe.

II. AXIOMATICS OF SYMMETRY AND ASYMMETRY FIELDS:

A. *Symmetry and Asymmetry of Bipolar Fields*:

We shall begin by stating the axiomatics of symmetry and *a*symmetry principles of *bipolar fields*, whose foundational basis we intend to employ in constructing a proposed conceptual model of elementary particles and fields of an emergent physical system. It is hoped that such a mathematically deductive approach is sufficiently general in scope so that it may find further applications in developing other physically-based, heuristic models in quantum field theory.

In the proposed axiomatic symmetry field theory, the distinction between local and global symmetry and *a*symmetry fields is somewhat arbitrary, since these designations are *scale dependent* with respect to spatial and temporal dimensions. Thus, what may appear to be a global symmetry field under one spatial or temporal scale may be regarded as a local symmetry field in another frame of reference.

Definition of a Bipolar Symmetry and Asymmetry Field:

A bipolar symmetry or *a*symmetry field is defined as a compact, bounded and denumerable array of symmetry elements, $s(k)(i)$, and their conjugate bipolar elements, $s^*(k)(i)$, (where k = a, b, c, d, . . . , i = 1, 2, 3, . . . n, for each *kth* symmetry class and *ith* element of the field.)

Definition of a Global Symmetry Field, S(k):

A global symmetry field, $\boldsymbol{S}(k)$, is composed of symmetry elements, $s(k)$ and it conjugate bipolar symmetry elements, $s^*(k)$, (where k = a, b, c, d, . . .), such that any compact, bounded and denumerable collection of $s(k)(i)$ and $s^*(k)(i)$, i = 1, 2, 3, . . . n, are *globally conserved*:

$\boldsymbol{S}(k)(i)$: $\quad s(k)(i) \iff s^*(k)(i)$ $\quad$ for each k = a, b, c, d, . . . ,
& i = 1, 2, 3, . . . n.

The designation of the global symmetry field, $\boldsymbol{S}(k)(i)$, represent different possible combinations of each globally conserved symmetrical state or class, k = a, b, c, d, ... It consists of an array of denumerable number of symmetry elements, *s*(k)(i), and their conjugates, *s**(k)(i), i = 1, 2, 3, . . . n, such that:

S(a)(i):	{*s*(a)(i) * *s**(a)(i)},
S(b)(i):	{*s*(b)(i) * *s**(b)(i)},
S(c)(i):	{*s*(c)(i) * *s**(c)(i)},
S(d)(i):	{*s*(d)(i) * *s**(d)(i)},
. . . . .	
and	
S(a,b)(i):	{*s*(a)(i) * *s**(a)(i)} * {*s*(b)(i) * *s**(b)(i)}
S(a,c,d)(i):	{*s*(a)(i) * *s**(a)(i)} * {*s*(c)(i) * *s**(c)(i)} * {*s*(d)(i) * *s**(d)(i)},
. . . . .	

Definition of a Local Symmetry Field, L(k):

A local symmetry field, ***L***(k), is composed of symmetry elements, *s*(k) and its bipolar conjugates, *s**(k), for each set of global symmetry fields, *S*(k), k = a. b, c, d, . . . , such that each pair of *s*(k)(i) and *s**(k)(i), for i = 1, 2, 3, . . . n, is *locally conserved* for the *bipolar composite*, [*s*(k)(i) *s**(k)(i)]:

L(k)(i): *s*(k)(i) * *s**(k)(i) <---> [*s*(k)(i) *s**(k)(i)] k = a, b, c, d, . . .
i = 1, 2, 3, . . . n

We may designate each denumerable array of bipolar composites, [*s*(k)(i)*s**(k)(i)], i = 1, 2, 3, . . . n, as the local field symmetry, ***L***(k)(i), for each kth global field symmetry, ***S***(k)(i), k = a, b, c, d, . . . :

L(a)(1):	[*s*(a)(1) *s**(a)(1)]
L(a)(2):	[*s*(a)(2) *s**(a)(2)]
. . . . .	
L(b)(1):	[*s*(b)(1) *s**(b)(1)]
L(b)(2):	[*s*(b)(2) *s**(b)(2)]
. . . . .	

Proposition 1:

For every local symmetry, ***L***(k,m)(i), to be *congruent* to a corresponding global symmetry, ***S***(k,m)(i), (where k,m = a, b, c, d, . . . and i = 1, 2, 3, . . . n), implies the *exact conservation* of all its symmetry elements, *s*(k,m)(i) and it bipolar conjugates, *s**(k,m)(i), such that:

s(k,m)(i) <=> *s**(k,m)(i) <=> [*s*(k,m)(i) *s**(k,m)(i)]

***Definition of Local Asymmetry Field*:**

If symmetry elements and their conjugates do not belong to a local symmetry field, ***L***(k,m)(i), (k,m = a, b, c, d, . . .) in form of a bipolar composite, [*s*(k,m)(i) *s**(k,m)(i)], they belong to a *local asymmetry field*, ***L***^(k,m)(i), consisting of *a*symmetrical elements, [*s*(k,m)(i)]^, and their conjugates, [*s**(k,m)(i)]^:

L(k,m)(i) <=/=> ***L***^(k,m)(i)
or
[*s*(k,m)(i) *s**(k,m)(i)] <=/=> [*s*(k,m)(i)]^ + [*s**(k,m)(i)]^

***LEMMA I*:**

Local symmetric fields, ***L***(k,m)(i), consisting of bipolar composites, [*s*(k,m)(i) *s**(k,m)(i)], but not consisting of any *a*symmetrical fields, ***L***^(k,m)(i), are *indistinguishable* from global symmetric fields, ***S***(k,m)(i), where k,m = a, b, c, d, . . ., and i = 1, 2, 3, . . . n:

L(k,m)(i) <=> ***S***(k,m)(i)

Proof: This lemma follows directly from definitions 1 and 2, and the application of proposition 1, which states the congruence of global and local symmetrical fields, ***L***(k,m)(i) and ***S***(k,m)(i), and the exact conservation of symmetry elements and their conjugates, *s*(k,m)(i) and *s**(k,m)(i).

***Corollary I-A*:**

Local *a*symmetric fields, ***L***^(k,m)(i), consisting of separated and non-composite symmetry elements [*s*(k,m)(i)] and [*s**(k,m)(i)], are *distinguishable* from global symmetric fields, ***S***(k,m)(i), where k,m = a, b, c, d, . . ., and i = 1, 2, 3, . . . n:

L^(k,m)(i) <=/=> ***S***(k,m)(i).

***Corollary I-B*:**

When local symmetric fields, ***L***(k,m)(i), consisting of bipolar composites, [*s*(k,m)(i) *s**(k,m)(i)], are displaced within a globally symmetric field, ***S***(k)(i), where k,m = a, b, c, d, . . ., and i = 1, 2, 3, . . . n, its displacements are *indistinguishable* with respect to the globally symmetric field, *S*(k,m)(i), and are defined as *non-inertial displacements*, *q*:***L***(k,m)(i):

q:***L***(k,m)(i): <---> ***L***(k,m)(i) <=> ***S***(k,m)(i)

Corollary I-C:

When local *a*symmetric fields, ***L***^(k,m)(i), consisting of *a*symmetric components, [*s*(k,m)(i)] and [*s**(k,m)(i)], are displaced within a globally symmetric field, ***S***(k,m)(i), where k,m = a, b, c, d, . . ., and i = 1, 2, 3, . . . n, its displacements are *distinguishable*, with respect to the globally symmetric field, *S*(k,m)(i), and are defined as *inertial displacements*, *q^:**L***^(k,m)(i):

*q^:**L***^(k,m)(i): <---> ***L***^(k,m)(i) <=/=> ***S***(k,m)(i)

B. <u>*The Transformation of Field Symmetries and Asymmetries*</u>:

Definition of Global Field Asymmetries, S^(k):

Global field symmetries, ***S***(k,m)(i), are transformed to global field *a*symmetries, ***S***^(k,m)(i), when symmetry elements, *s*(k,m)(i), and their bipolar conjugates, *s**(k,m)(i), are no longer indistinguishable from their globally symmetrical state, {[*s*(k,m)(i)] * [*s**(k,m)(i)]}:

S(k,m)(i) ---> ***S***^(k,m)(i)
or
[*s*(k,m)(i) *s**(k,m)(i)] <=/=> {[*s*(k,m)(i)] * [*s**(k,m)(i)]}

Definition of Local Field Asymmetries, L^(k):

Local field symmetries, ***L***(k,m)(i), are transformed to local *a*symmetric fields, ***L***^(k,m)(i), when symmetry elements, *s*(k,m)(i), and their bipolar conjugates, *s**(k,m)(i), of a globally symmetric field, ***S***(k,m)(i), are no longer present in their locally symmetrical composite states, [*s*(k,m)(i) *s**(k,m)(i)]:

L(k,m)(i) ---> ***L***^(k,m)(i)
or
[*s*(k,m)(i) *s**(k,m)(i)] ---> [*s*(k,m)(i)]^ + [*s**(k,m)(i)]^

Proposition 2:

Local field symmetries, ***L***(k,m)(i), (where k,m = a, b, c, d, . . .) in transforming to local field *a*symmetries, ***L***^ (k,m)(i), are indistinguishable from a set of global field *a*symmetries, **S**^(k,m)(i), if and only if they are *subsets* of global field symmetries, ***S***(k,m)(i):

L(k,m)(i) ---> ***L***^(k,m)(i) <=> ***S***^(k,m)(i) << ***S***(k,m)(i)

For example, for $\boldsymbol{S}$(k,m)(i), k = m = a, b, c, d, . . . and $\boldsymbol{S}$^(k,m)(i), k = b, c, d, . . . and m = a, we have:

$\boldsymbol{S}$(k,m)(i): {s(a, b, c, d, . . .)(i) * s*(a, b, c, d, . . .)(i)}
$\boldsymbol{S}$^(k,m)(i): {s(b, c, d, . . .)(i) * s*(b, c, d, . . .)(i)} * {[s(a)(i)] + [s*(a)(i)]}

where $\boldsymbol{S}$^(k,m)(i) *is congruent* to $\boldsymbol{S}$(k,m)(i) with respect to symmetry field elements, (b, c, d, . . .), and *is not congruent* with respect to symmetry field element, (a).

LEMMA II:

Global field *a*symmetries, $\boldsymbol{S}$^(k,m)(i), may only exist if and only if they are congruent to a set of local field *a*symmetries, $\boldsymbol{L}$^(k,m)(i), such that *global and local asymmetries of the field are indistinguishable from one another*:

$\boldsymbol{S}$^(k,m)(i) <=> $\boldsymbol{L}$^(k,m)(i)
or
{[s(k,m)(i)] * [s*(k,m)(i)]} <=> [s(k,m)(i) * s*(k,m)(i)]

Proof: This lemma follows from the above definitions of global and local *a*symmetric fields and from proposition 2, which states that global asymmetric fields are subsets of global symmetric fields, i.e., $\boldsymbol{S}$^(k,m)(i) << $\boldsymbol{S}$(k,m)(i), where k =/= m = a, b, c, d, ... Thus, if a locally *a*symmetrical field, $\boldsymbol{L}$^(k',m')(i), are congruent to a subset of a globally symmetrical field, $\boldsymbol{S}$^(k',m')(i), which is a subset of $\boldsymbol{S}$(k,m)(i), (k =/= m = a, b, c, d, . . . , and k' = m' = a, b, c, d, . . .), then global and local *a*symmetrical fields, $\boldsymbol{S}$^(k',m')(i) and $\boldsymbol{L}$^(k',m')(i) are indistinguishable to one another:

$\boldsymbol{S}$^(k',m')(i) <=> $\boldsymbol{L}$^(k',m')(i) for all k' = m' = a, b, c, d, . . .

Corollary II-A:

Globally *a*symmetrical fields, $\boldsymbol{S}$^(k,m)(i), are bounded and denumerable array of locally *a*symmetrical fields, $\boldsymbol{L}$^(k,m)(i), (k = m = a, b, c, d, . . .), such that every local *a*symmetric element, [s(k,m)(i)] or its bipolar conjugate, [s*(k,m)(i)], are congruent members of the globally symmetrical field:

$\boldsymbol{L}$^(k,m)(i):[s(k,m)(i)] <=> $\boldsymbol{S}$^(k,m)(i):[s(k,m)(i)]
$\boldsymbol{L}$^(k,m)(i):[s*(k,m)(i)] <=> $\boldsymbol{S}$^(k,m)(i):[s*(k,m)(i)]

Corollary II-B:

For every orthogonal series of globally *a*symmetrical fields, $\boldsymbol{S}$^(a)(i), $\boldsymbol{S}$^(b)(i), $\boldsymbol{S}$^(c)(i), . . . , there is an one-one correspondence to local *a*symmetrical fields, $\boldsymbol{L}$^(a)(i),

L^(b)(i), **L^**(c)(i), . . . , such that each locally *a*symmetrical field, **L^**(k,m)(i), is orthogonal and congruent to a corresponding globally *a*symmetric field, **S^**(k,m)(i), k = m = a, b, c, . . . :

S^(a)(i) <=> **L^**(a)(i)
S^(b)(i) <=> **L^**(b)(i)
S^(c)(i) <=> **L^**(c)(i)
. . . . .

Proposition 3:

There exists in every global field symmetry, **S**(k,m)(i), an ordinal and extensive *discontinuity* when local field *a*symmetries, **L^**(k,m)(i), transform globally symmetric fields to their *a*symmetrical state, **S^**(k,m)(i), k = m = a, b, c, d, . . ., such that *there is a congruence in local and global asymmetries*:

S(k,m)(i) ---> **S^**(k,m)(i) <=> **L^**(k,m)(i)

Proposition 4:

Every locally *a*symmetric field, **L^**(k,m)(i), when placed within a globally symmetric field, **S**(k,m)(i), *will tend to restore its local symmetry*, **L**(k,m)(i), such that symmetry elements, s(k,m)(i), and their conjugate bipolar elements, s*(k,m)(i), of the field *are both globally and locally conserved*:

[s(k,m)(i)] * [s*(k,m)(i)] ---> [s(k,m)(i) * s*(k,m)(i)]
or
L^(k,m)(i) ---> **L**(k,m)(i) <=> **S**(k,m)(i)

LEMMA III:

In every field consisting of symmetry elements, s(k,m)(i), and their conjugate bipolar elements, s*(k,m)(i), there are *an indefinite number of spatial and temporal discontinuities*, (x,t(j)), j = 1, 2, 3, . . ., at which global and local field symmetries, **S**(k,m)(i) and **L**(k,m)(i), and their corresponding *a*symmetries, **S^**(k,m)(i) and **L^**(k,m)(i), k = m = a, b, c, d, . . . , are *reciprocally transformed* into one another:

Symmetry-Asymmetry transforms:	*(x,t(j))*:	**S**(k,m)(i) ---> **S^**(k,m)(i)
	(x,t(j)):	**L**(k,m)(i) ---> **L^**(k,m)(i)
Asymmetry-Symmetry transforms:	*(x,t(j'))*:	**S^**(k,m)(i) ---> **S**(k,m)(i)
	(x,t(j')):	**L^**(k,m)(i) ---> **L**(k,m)(i)

Proof: This lemma follows directly from propositions 3 and 4, which separately state the reciprocal transformations of global and local field symmetries and *a*symmetries. These operations occur at indefinite number of ordinal and extensive discontinuities of the field, *x*(j) and *x*(j'), since there are an infinite array of probable global and local symmetrical and *a*symmetrical states that can be arrived at by the above transformations of the field.

Corollary III-A:

Local symmetry-asymmetry transforms, ***L***(k,m)(i) ---> ***L***^(k,m)(i), at spatial and temporal discontinuities, tend spontaneously to transform by *breaking* global symmetries to global *a*symmetries, ***S***(k,m)(i) ---> ***S***^(k,m)(i), such that local and global *a*symmetries are congruent to each other:

L(k,m)(i) ---> ***L***^(k,m)(i) ==> ***S***(k,m)(i) ---> ***S***^(k,m)(i)
such that:
L^(k,m)(i) <=> ***S***^(k,m)(i)

Corollary III-B:

Local asymmetry-symmetry transforms, ***L***^(k,m)(i) ---> ***L***(k,m)(i), tend spontaneously to transform by *restoring* local symmetry fields, ***L***(k,m)(i), as composite bipolar elements, [*s*(k,m)(i) * *s**(k,m)(i)], within a globally symmetric fields, ***S***(k,m)(i):

L^(k,m)(i) ---> ***L***(k,m)(i) <---> [*s*(k,m)(i) * *s**(k,m)(i)]

III. APPLICATIONS TO PHYSICAL SYSTEMS:

In this section, we shall apply the axiomatic framework of symmetry and *a*symmetry principles to a more physically-based kinematic and dynamic system. To begin with, we shall attempt to describe mechanical and electrodynamical parameters of physical systems that will be chiefly based on the definitions, propositions and lemmas we have developed and outlined above. We shall be using these newly formulated kinematical and dynamical principles in constructing a unified field theory of elementary particles and fields.

A. <u>Spatial and Temporal Displacements</u>:

The concept of *spatial displacements* of gauge-invariant locally symmetrical fields, ***L***(k,m)(i), within a globally symmetrical field, ***S***(k,m)(i), when parametrically measured in an orthogonal coordinate system, may be divided into two general categories:

1.) *Translational displacement*: in which the bipolar composite field elements, [*s*(k,m)(i) * *s**(k,m)(i)], of a locally symmetric field, ***L***(k,m)(i), are spatially displaced either

(a) as a *harmonic wave motion*, due to linear pertubation of locally symmetric field elements, *s*(k,m)(i) and *s**(k,m)(i), in a globally symmetric field, ***S***(k,m)(i); or

(b) as an *nth-order soliton*, due to non-linear pertubation of locally symmetric field elements, *s*(k,m)(i) and *s**(k,m)(i), in a globally symmetric field, ***S***(k,m)(i).

2.) *Rotational displacement*: in which the bipolar composite field elements, [*s*(k,m)(i) * *s**(k,m)(i)], of a locally symmetric field, ***L***(k,m)(i), are spatially displaced either

(a) as an *external angular motion* on a fixed axis of rotation of locally symmetric field elements, *s*(k,m)(i) and *s**(k,m)(i), in a globally symmetric field, ***S***(k,m)(i), or

(b) as an *internal angular (or isotopic spin) motion* on fixed axes (or loci) of motion of locally symmetric field elements, *s*(k,m)(i) and *s**(k,m)(i), in a globally symmetric field, ***S***(k,m)(i).

While the above descriptions of spatial displacements were derived for Cartesian coordinates (where the three external spatial and one temporal dimensions are parametrically separated), they are equally applicable to the four-dimensional *Lorentz-Minskowski* space-time manifold. In such a relativistic, gauge-invariant coordinate system -- upon which all quantum field theories are currently based -- all translational and rotational displacements of locally symmetrical elements are *naturally covariant* to Lorentz or Poincare transformations.

In the present axiomatic symmetry field theory, we describe *temporal displacements* (or dimension) as an *ordinal* measure of spatial displacements of locally symmetrical field elements, ***L***(k,m)(i). As an *external* field parameter, the temporal dimension is conventionally based on the ordinal measure of physical events with respect to relatively stable angular motions -- e.g., earth's diurnal and annual rotations. At sub-atomic ($<10^{-8}$ cm) and elementary particles ($<10^{-13}$ cm) spatial scale levels, we may also measure temporal displacements with respect to *internal* isotopic (or quantal) spin motions, as is implicitly embedded in relativistic quantum mechanical models (for example, the *CPT* theorem).

B. *Inertia and Mass*:

In axiomatic symmetry field theory, the concept of *inertia* is defined as the *intrinsic conservation* of bipolar composites of locally symmetric field elements, [*s*(k,m)(i) * *s**(k,m)(i)], within a globally symmetric field, ***S***(k,m)(i). The *resting or inertial mass*, $\mathbf{m}_0$(k,m)(i), of the locally symmetrical and asymmetrical fields are described as follows:

- For $\mathbf{m}_0$(k,m)(i) = 0, the locally symmetric field, ***L***(k,m)(i), composed of symmetric composite field elements, [*s*(k,m)(i) * *s**(k,m)(i)], is *indistinguishable from and congruent to* the globally symmetric field, ***S***(k,m)(i).

- For $\mathbf{m}_0$(k,m)(i) > 0, the locally *a*symmetric field, ***L^***(k,m)(i), composed of asymmetric field elements, [*s*(k,m)(i)] or [*s**(k,m)(i)], is *distinguishable from and is not congruent to* the globally symmetric field, ***S***(k,m)(i).

Thus, the resting mass of bipolar symmetric or *a*symmetric field elements (identified below as either bosonic or fermionic elementary particles) may be viewed as the *degree of inertial resistance* that occurs as locally symmetric or *a*symmetric fields, ***L***(k,m)(i) or ***L^***(k,m)(i), are spatially displaced in a globally symmetric field, ***S***(k,m)(i). For these reasons, only 'fully' symmetric bosonic particles may have resting masses, $\mathbf{m}_0$(k,m)(i) = 0 (where k = m = a, b, c, d, . . .). On the other hand, all *a*symmetric fermionic particles (by definition) must possess resting masses, $\mathbf{m}_0$(k,m)(i) > 0 (where k =/= m = a, b, c, d, . . .) (see below for specific examples).

C. *Kinematics and Dynamics of Symmetry Fields*:

Based on the above definitions of spatial (and temporal) displacements and resting (or inertial) mass, we may re-formulate the classical laws of translational and rotational motions in the language of axiomatic symmetry field theory as follows[2]:

> Principle of Symmetry Conservation: (*vis inertiae*) Every bipolar composite of locally symmetrical field elements, within a globally *symmetric* field, tends to remain in its *conserved state* of a gauge-invariant local symmetry (equivalent to the first law of motion).

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[2] The classical laws of motion as described by Isaac Newton in the *Principia* (1687) are: *First Law* "Every body continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it"; *Second Law* "The change of motion is proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed"; and *Third Law* "To every action there is always opposed an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts."

Principle of Symmetry Breaking: (*vis insita*) Spontaneously broken gauge-invariant local symmetries of field elements, within a globally symmetric field, leads to the formation of *second-order vector force field* (equivalent to the second law of motion).

Principle of Symmetry Restoration: (*vis ante-inertiae*) For every locally symmetric field element there is an conjugate bipolar field element, such that when brought together within a globally symmetric field, they *tend to restore* their gauge-invariant local symmetries (equivalent to the third law of motion).

Principle of Symmetry Equilibrium: (*vis viva*) The reciprocal creation of broken and restored gauge-invariant local symmetries of bipolar field elements, within a globally symmetric field, leads to the formation of *scalar and vector potentials* (an additional fourth law of motion).

From the above four symmetry field principles of translational and rotational motions, we may discern the underlying kinematics and dynamics of physical systems as follows:

• *Conservation of linear momentum* (symmetry conservation): occurs for *kinematic* motions, since locally symmetric or asymmetric fields, ***L***(k,m)(i) or ***L^***(k,m)(i), are either locally and/or globally conserved when they are spatially displaced against a globally symmetric field, ***S***(k,m)(i), whose translational motion may be described as a *first-order* differential equation at *constant velocity*, ***v***(k,m)(i):

$$\{\mathbf{m}_0(\mathrm{k,m})(\mathrm{i}) * [\mathbf{d}(t)]:(x)\} = 0$$

where $[\mathbf{d}(t)]:(x)= \boldsymbol{v}(\mathrm{k})(\mathrm{i})$, is the differential operator for *linear* spatial displacements (x) with respect to the temporal (t) dimension.

• *Conservation of angular momentum* (symmetry conservation): occurs for *dynamic* motions, since locally symmetric or asymmetric fields, ***L***(k,m)(i) or ***L^***(k,m)(i), are either locally and/or globally conserved when they are spatially displaced against a globally symmetric field, ***S***(k,m)(i), whose rotational or angular motions may be described as a *first-order* differential equation at *constant angular velocity*, $\boldsymbol{v}^a$(k,m)(i):

$$\{\mathbf{m}_0(\mathrm{k,m})(\mathrm{i}) * [\mathbf{d}(t)]:(\theta)\} = 0$$

where $[\mathbf{d}(t)]:(\theta)= \boldsymbol{v}^a(\mathrm{k,m})(\mathrm{i})$, is the differential operator for *angular* spatial displacements $(\theta) = \{(x)/(r)\}$, where (r) is the invariant *axial* displacement, with respect to the temporal dimension (t).

• *Vector Force Fields* (broken symmetry) comes into existence for all *dynamic* motions, whenever locally asymmetric fields, ***L^***(k,m)(i), created by spontaneous breaking of local symmetry fields, ***L***(k,m)(i), are spatially displaced against a globally symmetric field, ***S***(k,m)(i), whose translational (or angular) motions may be described as a *second-order* (or *first-order*) differential equation at *constant velocity*, ***v***(k,m)(i) (or *constant angular velocity*, ***v'***(k,m)(i)):

$$\{\mathbf{m}_0(\mathrm{k,m})(\mathrm{i}) * [\mathbf{d}^2(t)]:(x)\} = 0$$

or

$$\{\mathbf{m}_0(\mathrm{k,m})(\mathrm{i}) * [\mathbf{d}(t)]:(\theta)\} = 0$$

where $[\mathbf{d}^2(t)]:(x)\} = \boldsymbol{v}(\mathrm{k,m})(\mathrm{i})$ and $[\mathbf{d}(t)]:(\theta) = \boldsymbol{v}^a(\mathrm{k,m})(\mathrm{i})$, are second- and first-order differential operators for *translational* (x) and *angular* spatial displacements (θ) with respect to the temporal dimension (t), respectively.

• *Scalar and Vector Potentials* (broken and restored symmetries): are dynamical manifestations of reciprocal interchanges of locally broken and restored symmetry fields, ***L^***(k,m)(i) and ***L***(k,m)(i), within a globally symmetric field, ***S***(k,m)(i). Broken and restored local symmetry elements, [*s*(k,m)(i)] or [*s**(k,m)(i)] and [*s*(k,m)(i)] * [*s**(k,m)(i)], when placed within a globally symmetric field, ***S***(k,m)(i), are conceptually related to the *commutators* of creation and annihilation operators, {**[a**(k,m)(i,j)**]:** ,**[a***(k,m)(i,j)**]:**} (i,j = 1, 2, 3, . . .), that describe fundamental relationships of second quantized, gauge-invariant models in quantum field theory:

$$\{[\mathbf{a}(\mathrm{k,m})(\mathrm{i,j})]: ,[\mathbf{a}^*(\mathrm{k,m})(\mathrm{i,j})]:\} = \pm\, n(\mathrm{k,m})\ \delta(\mathrm{i,j})$$

where n(k,m) (n = 0, 1, 2, . . .) is a *characteristic scalar invariant* with respect to a local symmetry field, ***L***(k,m)(i), and δ(i,j) is the Knonecker delta.

For example, for spin(1/2) fermionic particles related to locally *a*symmetric fields, ***L^***(k,m)(i), that follow Fermi-Dirac statistics, we have *anti-commutators*, where n = - 2.

D. Harmonic and Solitonic Wave Motions:

As mentioned previously, all spatial and temporal displacements of locally symmetric or asymmetric fields, ***L***(k,m)(i) and ***L^***(k,m)(i), occur either as a harmonic or a solitonic wave motion (Goldstein, 1980):

• *Wave Motion of the Field*: occurs as a *linear perturbation* of a local symmetry or asymmetry field, ***L***(k,m)(i) and ***L^***(k,m)(i), leading to *localized vibrational motion*, within a globally symmetric field, ***S***(k,m)(i). Such a wave motion of the field may be described by a differential equation that is *second-order* with respect to both spatial and temporal dimensions. It is defined by a *characteristic velocity*, *c*(k,m), of wave transmission, which remains *invariant* in each globally symmetric field, ***S***(k,m)(i):

$$[\mathbf{d}^2(t)]:(\psi)(\mathrm{k,m})(\mathrm{i}) \quad = \quad \{c^2(\mathrm{k,m})\} * [\mathbf{d}^2(x)]:(\psi)(\mathrm{k,m})(\mathrm{i})$$

where (ψ)(k,m)(i) is the *amplitude* of spatial (x,one dimensional) and temporal displacements (t).

For (3 + 1)-dimensional Cartesian space-time coordinate systems and 4-dimensional Lorentz-Minkowski space-time manifolds, we merely substitute the above wave equations with the corresponding *Laplacian* and *D'Alembertian* differential operators, respectively.

• *Solitonic Wave Equation*: occurs as a *non-linear perturbation* of a local symmetry or asymmetry field, ***L***(k,m)(i) and ***L***^(k,m)(i), leading to a *localized translational displacement* -- i.e., non-vibratory, solitary wave motion -- across a globally symmetric field, ***S***(k,m)(i). Solitonic wave motion may be described by a differential equation that is *nth-order* (n = 2q + 1, where q = 1, 2, 3, . . .) with respect to spatial dimensions (x) (one dimensional) and *first-order* to temporal dimensions (t) (Drazin and Johnson, 1989)[3]:

$$[\mathbf{d}(t)]:(\psi)(\mathrm{k,m})(\mathrm{i}) \quad = \quad \{-\ (\alpha)[\mathbf{d}^n\ (x)]:(\psi)(\mathrm{k,m})(\mathrm{i})\} + [\boldsymbol{\Sigma}]:\{(K(x,t))[\mathbf{d}^{n-1}(x)]:(\psi)(\mathrm{k,m})(\mathrm{i}) + [\mathbf{d}^{n-1}(x)]:(\psi)(\mathrm{k,m})(\mathrm{i})(K(\mathrm{x,t}))\} + \{(K'(t))\}$$

where (α) is a scalar invariant, and $(K(x,t))$ and $(K'(t))$ are characteristic parameters for each solitonic wave equation of order (n,q).

In general, non-linear solitonic wave equations described above (known as Lax formulations), with *dispersive* characteristics, have solutions for n = 3, 5, 7, . . . , corresponding to q = 1, 2, 3, ... The simplest soliton in this formulation is given by the *Korteweg-de Vries (KdV) equation*, for n = 3, q = 1:

$$[\mathbf{d}(t)]:(\psi)(\mathrm{k,m})(\mathrm{i}) \quad = \quad \{-\ (\alpha)[\mathbf{d}^3(x)]:(\psi)(\mathrm{k,m})(\mathrm{i})\} + \{(K(x,t))[\mathbf{d}(x)]:(\psi)(\mathrm{k,m})(\mathrm{i}) + [\mathbf{d}(x)]:(\psi)(\mathrm{k,m})(\mathrm{i})(K(\mathrm{x,t}))\} \quad + \{(K'(t))\}$$

where $(\alpha) = 4$, $(K(x,t)) = 3$ and $(K'(t)) = 0$ are the characteristic parameters for KdV equation of order (3,1).

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[3] Other types of solitonic wave equations should also be mentioned: *Sine-Gordon equation* (second-order wrt to space and time, with non-linear source term); *Burgers equation* (non-linear, *dissipative* equation); *non-linear Schrodinger equation* (incorporating scale-dependent complex terms), etc.

In contrast to harmonic wave motions, which possess invariant characteristic velocities of spatial displacements, ***c***(k,m), solitonic wave velocities, ***c'***(k,m), are *not invariant* with respect to globally symmetric fields, ***S***(k,m)(i). For example, soliton wave velocities are *directly proportional to the amplitudes*, (ψ)(k,m)(i) of locally symmetric or asymmetric fields, ***L***(k,m)(i) and ***L^***(k,m)(i) (Drazin and Johnson, 1989).

E. <u>Quantum Mechanical Wave Equations</u>:

In order to obtain quantum mechanical wave equation for locally asymmetric fields, ***L^***(k,m)(i), we substitute spatial coordinates, (*q*(i)), linear momentum, (*p*(i)), angular momentum, (*a*(i)) and the Hamiltonian function, (*H*(*q*)(*p*)), of classical mechanics by self-adjoint, canonically-conjugate complex operators, as follows (Davydov, 1976):

(*q*(i))	--->	(*q*(i))	**[q**(i)**]:**
(*p*(i))	--->	**(*h*$_e$/[i])[*d*(*q*(i)]:**	**[p**(i)**]:**
(*a*(i))	--->	**(*h*$_e$/[i])**{(*q*(j))**[*d*(*q*(k)]:** - (*q*(k))**[*d*(*q*(j)]:**}	**[a**(i)**]:**
(*H*(*q*)(*p*))	--->	**(*h*$_e$/[i])[*d*(*t*)]:**))	**[H**(*q*)(*p*)**]:**

where **[q**(i)**]:**, **[p**(i)**]:**, **[a**(i)**]:** and **[H**(*q*)(*p*)**]:** (i,j,k = 1, 2, 3, . . .) are the *quantized* spatial coordinate, linear momentum, angular momentum and Hamiltonian function operators, respectively. Here (***h***$_e$) is the rotationally normalized Planck's constant (equal to {(***h***$_e$')/2π}, where (***h***$_e$') is the *quantum of action* for the photonic field (see below), and **[i]** is the orthogonality operator for complex scalars.

Employing the above quantized dynamical variables, we may derive the following quantum mechanical equations of motion of locally symmetric fields, ***L^***(k,m)(i), within a globally symmetric field, ***S***(k,m)(i):

- *Schrodinger Wave Equation*: which is a general *non-relativistic* linear differential equation that is *second-order* to spatial coordinates (*q*), and *first-order* to the temporal dimension (*t*):

  [H(*q*),(*p*)**]:** {(ψ>} = {(*E*(*q*),(*p*) * {(ψ>}

  where (ψ> is the wave amplitude or *eigenfunction* of the dynamical system, **[H**(*q*),(*p*)**]:** is the Hamiltonian function operator, and (*E*(*q*),(*p*) is a corresponding set of energy *eigenvalues*.

• *Klein-Gordon Equation*: which is a *relativistic* differential equation that is *second-order* to both spatial coordinates (q) and the temporal dimension (t), and is only applicable to spin(0) particles (in natural units, $\boldsymbol{h_e} = \boldsymbol{c_e} = 1$):

$$[\mathbf{d}^2(t)]:]\ \{(\psi>\}\ =\ \{[\mathbf{d}^2(q)]:\ -\ (m_o)^2\}\{(\psi>\}$$

where (m_o) is the rest mass of the elementary particle and $(\psi>$ is the *eigenket* (wave amplitude) of the dynamical system.

• *Dirac Equation*: which is a *relativistic* differential equation that is *first-order* with respect to both spatial coordinates, (q), and the temporal dimension (t). It is generally applicable to spin(1/2) particles ($\boldsymbol{h_e} = \boldsymbol{c_e} = 1$):

$$([\mathbf{d}(t)]:\ +\ [\Sigma(\mathrm{i})]:\{[\boldsymbol{\alpha}(\mathrm{i})]\ *\ [\boldsymbol{d}(q)]:\}\ +\ \{[\mathbf{i}](m_o)\ *\ [\boldsymbol{\beta}(\mathrm{j})]\})\ (\boldsymbol{\Phi})\ =\ 0$$

where $[\boldsymbol{\alpha}(\mathrm{i})]$ and $[\boldsymbol{\beta}(\mathrm{j})]$ (i = 1,2,3 and j = 4), are the *Dirac matrices*, which are composed of the *Pauli matrices*, $[\boldsymbol{\sigma}(\mathrm{i})]$ (i = 1,2,3), as irreducible sub-sets. Here $[\Sigma(\mathrm{i})]$**:** is the algebraic summation operator and $(\boldsymbol{\Phi})$ is a four-component column matrix (4-spinor).

F. ***Elementary Particles and Symmetry Fields***:

We shall now state a proposition of axiomatic symmetry field theory that all kinematic and dynamic systems have *two* fundamental entities that are inextricably linked to one another: *localized elementary particles and global symmetry fields*. As stated above, we have defined global fields, ***S***(k,m)(i) or local fields, ***L***(k,m)(i), as compact and bounded set of symmetry elements and their conjugate bipolar elements, *s*(k,m)(i) and *s**(k,m)(i). Each globally symmetrical field, ***S***(k,m)(i), is an finite array of locally symmetrical fields, ***L***(k,m)(i), which consists of bipolar composites, [*s*(k,m)(i) * *s**(k,m)(i)].

We shall now define each locally symmetrical composite as a field particle, ***P***(k,m)(i), designated here as a *boson*, that is a locally symmetrical field, ***L***(k,m)(i), k = a, b, c, d, . . . , with respect to the *kth* symmetry class within a globally symmetric field, ***S***(k,m)(i). Similarly, each locally asymmetrical field, ***L^***(k,m)(i), consisting of *a*symmetric elements, [*s*(k,m)(i)] or [*s**(k,m)(i)], is defined as a field particle, ***P^***(k,m)(i), designated as a *fermion*:

Bosons, ***P***(k,m)(i): ***L***(k,m)(i) <=> [*s*(k,m)(i) * *s**(k,m)(i)]

<=> ***S***(k,m)(i)

Fermions, ***P^***(k,m)(i): ***L^***(k,m)(i) <=> [*s*(k,m)(i)] *or* [*s**(k,m)(i)]

<=/=> S(k,m)(i)

Following convention, we shall designate bosons, P(k,m)(i), with *internal* angular momentum or quantal spin number, s(n), n = 0, 1, 2, . . . , and fermions, P^(k,m)(i), with quantal spin number, s^(n), n = 1/2, 3/2, 5/2, ...

As defined previously, bosonic particles, P(k,m)(i), have vanishing resting masses, if their locally symmetric field, L(k,m)(i), are indistinguishable from the globally symmetric field, S(k,m)(i), for all k = m = 1, 2, 3, ... In addition, the characteristic wave velocities, c(k,m), of harmonic motion of locally symmetric bosonic particles are the *upper limiting velocity* of all wave transmissions in the globally symmetric field, S(k,m)(i). For example, the photon has a zero resting mass ($m_o = 0$) in the globally symmetric vacuum state of the electromagnetic field. In addition, the Lorentz transform equations of special relativity theory precludes locally *a*symmetric fermionic particles -- such as electrons or positrons (resting mass, $m_o > 0$) that display wave-like transmissions or polarized currents -- from having their characteristic harmonic wave velocities, c_e^(k,m), from exceeding the velocity of photonic transmissions, c_e(k,m), i.e.,

c_e^(k,m) < c_e(k,m) for all L^(k,m)(i) <=/=> S(k,m)(i)

However, there are no conceptual basis for believing that such strict limitations on transmission velocities equally apply to solitonic wave motions of fermionic particles, since the locally asymmetric field, L^(k,m)(i), is translationally (and not vibrationally) displaced across the globally symmetric field, S(k,m)(i) (see later discussions on this important unanswered question).

G. *Unified Field Theory -- General Considerations*:

The proposed unified field theory is based on the dynamical properties of elementary particles and symmetry fields that were outlined above. It postulates the existence of global and local symmetry fields and bipolar elements that may be schematically presented as follows:

- Globally symmetric fields, S(k,m)(i), exist in a *nested hierarchy of symmetry classes*, k = or =/= m = a, b, c, d, . . . , consisting of denumerable number of symmetry and *a*symmetry elements, *s*(k,m)(i) and *s**(k,m)(i) (i = 1, 2, 3, . . .), whose locally symmetry fields, L(k,m)(i), are transformed to their globally and locally *a*symmetric fields, S^(k,m)(i) and L^(k,m)(i), in accordance to:

. . . . .

S(. . . a/a*, b/b*, c/c*, d/d*, . . .)(i)

$<--->\ \boldsymbol{L}(\ldots a/a^*, b/b^*, c/c^*, d/d^*, \ldots)(i)$

$\boldsymbol{S}_a\text{^}(\ldots [a]:[a^*], b/b^*, c/c^*, d/d^*, \ldots)(i)$

$<--->\ \boldsymbol{L}_a\text{^}(\ldots [a]:[a^*], b/b^*, c/c^*, d/d^*, \ldots)(i)$

$\boldsymbol{S}_{a,b}\text{^}(\ldots [a]:[a^*], [b]:[b^*], c/c^*, d/d^*, \ldots)(i)$

$<--->\ \boldsymbol{L}_{a.b}\text{^}(\ldots [a]:[a^*], [b]:[b^*], c/c^*, d/d^*, \ldots)(i)$

. . . . .

where (. . . a/a*, b/b* . . .) and (. . . [a]:[a*], [b]:[b*] . . .) designate symmetry and *a*symmetric field elements, (a,a*) and (b,b*), respectively. Here $\boldsymbol{S}_a,\boldsymbol{S}_{a,b}$^, $\boldsymbol{L}_a$^, $\boldsymbol{L}_{a.b}$^, etc., denote the global and local asymmetric states with respect to (. . . [a]:[a*], b/b*, . . .) and (. . . [a]:[a*], [b]:[b*], . . .), etc.

• In the above nested hierarchies of symmetry fields, transformation of globally symmetrical to asymmetrical fields, ***S***(k,m)(i) ---> ***S***^(k,m)(i), occurs at certain space-time discontinuities, so that there is a *temporal order or evolution* of symmetry breaking field events, i.e., {(a/a*) ---> [a]:[a*]} *before* {(b/b*) ---> [b]:[b*]}, etc.:

$\boldsymbol{S}(\ldots a/a^*, b/b^*, \ldots)(i)\ \ --->\ \ \boldsymbol{S}_a\text{^}(\ldots [a]:[a^*], b/b^*, \ldots)(i)$

$--->\ \ \boldsymbol{S}_{a,b}\text{^}(\ldots [a]:[a^*], [b]:[b^*], \ldots)(i), \ldots$ & etc.

• We shall now apply the unified field model to current phenomenology by describing the following proposed hierarchies of global and local symmetry states:

(i) *dark matter symmetry fields*, (*d*/*d**), consisting of dark matter bipolar symmetry elements, [*d*] and [*d**]. It is hypothesized that these extremely weakly-interacting symmetry elements, that preceded the transformation of globally symmetric gravitational fields, are associated with dark matter particles and fields which are responsible for spatially long-ranged intra- and inter-galactic dynamics.

(ii) *gravitational symmetry fields*, (*g*/*g**), consisting of gravitational bipolar symmetry elements, [*g*] and [*g**]. It is assumed that these gravitational symmetry elements are counterparts of the local bipolar electric charge symmetries that define the photonic field (as discussed below). Thus, the spin(2) graviton is a locally symmetric field consisting of the bipolar composite, [(*g*) * (*g**)].

(iii) *helicity symmetry fields*, (*h*/*h**), consisting of helicity (or chiral) bipolar symmetry elements, [*h*] and [*h**]. These symmetry elements describe the helicities or chiral polarity of bosons and fermions, including all leptons and hadrons. It is an *internal spin state* that describes the existence of weak force fields (see below).

(iv) *electric charge symmetry fields*, (*e*/*e**), consisting of quantal negative and positive electric charges of leptons and hadrons, [*e*] and [*g**]. The globally symmetric electrically charged fields are identified as the electromagnetic (or photonic) field, ***S***(*e*/*e**), consisting of photons as its locally bipolar symmetric field, ***L***(*e*/*e**).

(v) *color charge symmetry fields*, {*c*(1)/*c**(1); *c*(2)/*c**(2); *c*(3)/*c**(3)] consisting of a group of three color and anti-color charges, [*c*(1)], [*c**(1)]; [*c*(2)], [*c**(2)]; and [*c*(3)], [*c**(3)]. These three color and anti-color charges are equivalent to red, blue and green colors and anti-color charges in different flavor of quarks that are postulated in QCD theory. They are locally asymmetric *only* in hadrons (baryons and mesons), e.g,, they are responsible for the residual isotopic spin states of the strong force field in the atomic nucleus.

• As mentioned earlier, we may identify each of the above globally symmetric field, ***S***(k,m)(i), with a *characteristic wave velocity*, ***c***(k,m), that measures the limiting rate of transmission of the locally symmetric field bosons. For example, we may define a characteristic wave velocities for the dark matter field, $\boldsymbol{c}_{d}$, gravitational field, $\boldsymbol{c}_{g}$., helicity field, $\boldsymbol{c}_{h}$, electromagnetic field, $\boldsymbol{c}_{e}$, gluonic color field, $\boldsymbol{c}_{c}$,, such that:

$$\ldots\ \boldsymbol{c}_{d} > \boldsymbol{c}_{g.} > \boldsymbol{c}_{h} > \boldsymbol{c}_{e} > \boldsymbol{c}_{c}\ \ldots$$

These decreasing wave velocities of the globally symmetric fields occurs because the intrinsic resting mass, ($\boldsymbol{m}_o$)(. . . *d*/*d**, *g*/*g**, *h*/*h**, *e*/*e**, *c*/*c**, . . .), of each locally symmetric particle, ***P***(k,m)(i), where k =/= m = . . . , *d*/*d**, *g*/*g**, *h*/*h**, *e*/*e**,*c*/*c** , . . . , with respect to the globally symmetric field, ***S***(k,m)(i) *decreases* as we move down the transformed symmetry broken sequence of bosonic particles[4]:

Dark matter boson: $\boldsymbol{P}_d$(. . . *d*/*d**, *g*/*g**, *h*/*h**, *e*/*e**, *c*/*c**, . . .)

Graviton: $\boldsymbol{P}\hat{}_g$(. . . [*d*]:[*d**], *g*/*g**, *h*/*h**, *e*/*e**, *c*/*c**, . . .)

Photon: $\boldsymbol{P}\hat{}_e$(. . . [*d*]:[*d**], [*g*]:[*g**], *h*/*h**, *e*/*e**, *c*/*c**, . . . }

[4] It should be noted that the neutrino while appearing as locally symmetric boson here with respect to the globally symmetric electric charge, it is a fermion, with respect to the photonic field, where the helicity is locally symmetric in the bosonic photon.

Neutrino: $P^{\wedge}_{h}$(. . . [*d*]:[*d**], [*g*]:[*g**], [*h*]:[*h**], *e*/*e**, *c*/*c**, . . .),

. . . . . & etc.

where (. . . [*d*]:[*d**], [*g*]:[*g**], [*h*]:[*h**], . . .), designate broken and asymmetric field elements, and (. . . *d*/*d**, *g*/*g**, *h*/*h**, *e*/*e**, *c*/*c**, . . .) represents retained or unbroken symmetry elements.

H. Unified Electromagnetic-Weak Field, EW(k):

More detailed applications of the above model leads us to define a unified electromagnetic-weak field, ***EW***(k), and its bosonic and fermionic particles as follows:

• We shall begin by designating *two* bipolar symmetry elements to be present in the electromagnetic-weak field: (i) *electric charges*, *e* and *e**, and (ii) *helicity*, *h* and *h**, i.e., k = m = *e*/*e** and *h*/*h**. All other symmetry fields, such as dark matter, gravitational and color charge symmetry elements will be ignored in this discussion.

• We shall postulate that a globally symmetrical ***EW***(k) field is composed of the following *bosonic* particle: ***P***(*e*/*e**, *h*/*h**). We will identify this particle to be the massless *photon*, with its two intrinsic *polarized* states (*h* and *h**) and its possession of *electro-neutrality* (*e*/*e**).

• Next, we postulate that when the bosonic photon, ***P***(*e*/*e**, *h*/*h**), transforms *by spontaneously breaking its local symmetry* to a series of *locally asymmetrical field particles*, ***P^***(k), we obtain the following set of *fermionic and bosonic particles* in the ***EW***(k) field:

(a) ***P^***(*e*/*e**, *h*), identified with a *right-handed anti-neutrino*,
(b) ***P^***(*e*/*e**, *h**), identified with a *left-handed neutrino*,
(c) ***P^***(*e*, *h*) and ***P^***(*e*, *h**), identified with *right- and left-handed electrons*, and
(d) ***P^***(*e**, *h*) and ***P^***(*e**, *h**), identified with *right- and left-handed positrons*.

• Additionally, we observe the formation of the following set of *vector boson particles*, ***P***(k), which occurs by the tendency of *complete or partial restoration of symmetries* at the local (gauge invariant) level:

(a) ***P***(*e*/*e**, *h*/*h**), identified with *photons*, that occurs by *complete restoration* of local symmetries,
(b) ***P***(*[e/e*,h]:[e/e*,h*]*), identified with Z^0 *vector boson particle*, by *partial restoration* of local symmetries,
(c) ***P***(*[e/e*,h]:[e*,h*]*) or (*[e/e*,h*]:[e*,h]*), identified with *W(+) vector boson particle*, by *partial restoration* of local symmetries, and
(d) ***P***(*[e/e*,h*]:[e*,h]*) or (*[e/e*,h]:[e*,h*]*), identified with *W(-) vector boson*

particle, by *partial restoration* of local symmetries.

In the above formulation, we see how naturally we arrive at the non-conservation of parity among neutrinos. Parity has been traditionally defined in terms of helicity (or chilarity) of elementary particles. In this instance, each symmetry element in the electro-neutral neutrino and anti-neutrino (consisting of locally symmetric electrical charge conjugation, *e/e**) can exist at the locally asymmetric level in either the *h* or *h** helicity states, i.e., ***P^***(*e/e*, h*) or ***P^***(*e/e*, h**). For these reasons, we find *only* left-handed neutrinos and right-handed anti-neutrinos in the physical universe.

I. <u>***Electric and Magnetic Field Symmetries and Asymmetries***</u>:

In this application, we shall delineate the symmetry and asymmetry elements that are embedded in Maxwell's equation that describe electrostatic and electrodynamic field phenomena. There are *four* possible types of global and local symmetry relationships between electric charges, (*e*) and (*e**), in a globally symmetric photonic or electromagnetic field, ***E***(k), (k = *e/e*, h/h**) consisting of photons, ***P***(*e/e*, h/h**):

- ***L***(k) <---> ***S***(k): Locally symmetric electric fields, ***L***(*e/e*, h/h**), in a globally symmetric field, ***S***(*e/e*, h/h**). This represents the presence of locally symmetric *photons* in a background of an electromagnetic field, ***E***(k), in its symmetrical photonic vacuum state.

- ***L^***(k) <---> ***S***(k): Locally *a*symmetric electric fields, ***L^***(*e,h**) or (*e*,h*), in a globally symmetric field, ***S***(*e/e*, h/h**). This represents the presence of *electrons or positrons* in a globally symmetric electromagnetic field, ***E***(k). Here the electric charges, (*e,h**) and (*e*,h*), tend to confer *field asymmetries* to the symmetrical photonic field in following manner:

    (a) *Electrostatic fields*: through vacuum polarization of locally symmetric photonic elements of the electromagnetic field. Thus, we replace *'virtual'* particles of quantum field theories by '*real*' locally asymmetric particles, i.e., by *short-lived* electrons and positrons that are created (transformed asymmetries) and annihilated (restored symmetries) in the globally symmetric photonic field.

    (b) *Electrodynamic fields*: either by spatial displacement (e.g., flow of electric currents, **j**(*e*)) or by harmonic oscillations (e.g., perturbation of electric dipole moments, **m**(*e*)) of locally asymmetric electrically charged fields, ***L^***(*e,h*) or (*e,h**). In addition to the creation of a globally *a*symmetric *electric field*, **E**(i), we also form a globally *a*symmetric *magnetic field,* **B**(i). The magnetic field is *orthogonal to both* the vector-orientation of the electric field and the vector-displacement of the electric current.

• L^(k) <---> S^(k): Locally *a*symmetric electric fields, L^(e,h) or (e,h*), in a globally *a*symmetric field, S^(e, h/h*) or (e*, h/h*). This represents the formation of *magnetic fields*, **B**(i), in a time independent *ferro-magnetic field*, **FM**(i). Here the globally asymmetric magnetic field is created through the vacuum polarization of symmetric photonic field elements by locally asymmetric field elements, i.e., the 'permanent' (time independent) magnetic moments of locally asymmetric ferro-magnetic fields.

• L(k) <---> S^(k): Locally symmetric electric fields, L(e/e*, h/h*), in a globally asymmetric field, S^(e, h/h*) or (e*, h/h*). This represents the spontaneous creation of electron/positron pairs, ([e, h*] * [e*, h]), from locally symmetrical positronium particles, ([(e,h*)(e*,h)], when placed within globally asymmetric electric or magnetic fields, **E**(i) or **B**(i).

In addition to the above four symmetry-*a*symmetry bipolar combinations of the electromagnetic field, we should include the following *spatial- and spin-related* symmetry relationships:

• L(r):L^(k) <---> S^(k): Locally *a*symmetric electric fields that are *symmetric to rotational displacement*, L(r):L^(e,h) or (e,h*), placed within a globally *a*symmetric field, S^(e, h/h*) or (e*, h/h*). This represents the *induction of electric currents*, **j**(e), to the time-varying spatial displacements of the globally *a*symmetric magnetic fields, **B**(i). In this instance, the local *a*symmetries of electrons, L^(e,h) or (e,h*), which are spatially symmetric to rotational displacements, L(r), becomes spatially *a*symmetric, L^(r), to the direction of the induced electric current, L^(r):L^(e, h/h*).

• L(s/s*):L^(k) <---> S^(k): Locally *a*symmetric electric fields that are symmetric to electron spin, L(s/s*):L^(e,h) or (e,h*), placed within a globally asymmetric field, S^(e, h/h*) or (e*, h/h*). This represents the induction of *super-conducting electric currents*, **j**(s/s*)(e), to globally *a*symmetric magnetic fields, **B**(i). Here the formation of local spin-symmetric electron bipolar elements, L(s/s*):L^(e,h) or (e,h*), known as *Cooper Pairs*, are identical (at low temperatures) in their spin-symmetries to the globally *a*symmetric electron conducting medium, S(s/s*):S^(e,h/h*), i.e.,

L(s/s*):L^(e,h/h*) <=> S(s/s*):S^(e,h/h*)

IV. EVOLUTION AND EMERGENCE OF THE PHYSICAL, CHEMICAL AND BIOLOGICAL UNIVERSE:

We shall now examine the conceptual principles presented above in an attempt to understand how relatively stable and ordered matter emerged in an evolving physical universe. We shall also briefly discuss how these symmetry field principles may be applied to more complex chemical and biological systems. The overall approach here is conceptual and qualitative, with no attempt to be exhaustive with respect to specific questions or unresolved problems in the physical, chemical or biological sciences.

A. Physical Cosmology and Symmetry Fields:

We will begin by assuming that the physical universe was at one time in a state of high global symmetry, so that it was essentially featureless in its primordial vacuum state. In such a physical state, the local symmetry fields (as defined above), including all pre-dark matter symmetry elements, $\boldsymbol{L}(\ldots \alpha/\alpha^*, \beta/\beta, \gamma/\gamma^*, \ldots, d/d^*, g/g^*, h/h^*, e/e^*, c/c^*, \ldots)$ are *indistinguishable* from the globally symmetric field, $\boldsymbol{S}(\ldots, \alpha/\alpha^*, \beta/\beta, \gamma/\gamma^*, \ldots, d/d^*, g/g^*, h/h^*, e/e^*, c/c^*, \ldots)$. Let us now endow each symmetry element, *s*(k,m)(i) and *s**(k,m)(i), of the globally symmetric field, ***S***(k,m)(i), with an internal spin or equivalently by an angular momentum vector state. We shall stipulate that the internal spin state is *scale invariant* (with respect to space and time), and is represented by a field parameter known as the *characteristic quantum of action*, ***h***(k,m)(i). Thus, each global symmetry field will be represented by a specific quantum of action that defines its retained, broken or restored symmetry states. For example, the electromagnetic (or photonic) field is described by the Planck's constant, $\boldsymbol{h}_e$, (with its mass-space-time dimensions of angular momentum or action) which had been first introduced in connection with the distribution of electromagnetic radiant energies from a perfect black-body (hohlraum). Here, $\boldsymbol{h}_e$ as the quantum of action may be viewed as vector spin state of the electric charge symmetry element, [*e*], which together with its anti-spin state, [*e**], make up the locally symmetric photonic field element, $\boldsymbol{P}(\ldots e/e^*, h/h^* \ldots)$.

In the above scenario, while the globally symmetric vacuum state of the primordial universe appears to be devoid of physical features, such as manifest kinetic or potential energies, its Lagrangian densities (or action integrals) are dynamically hidden or masked by being embedded in the internal spin states of its locally symmetric bipolar field elements, *s*(k,m)(i) and *s**(k,m)(i). Thus, the physical universe may be said to possess a *latent scalar potential*, (Φ), in its globally symmetric vacuum state. In addition, such a physical universe, with its high degree of congruence between local and global bipolar symmetries, is also in an equilibrium state of extremely high entropy. On the other hand, if we examine such a globally symmetric vacuum state at a sufficiently small spatial scale (e.g., $< 10^{-120}$ cm), we may discern broken local symmetries (or quantum fluctuations) of a series of pre-dark matter fields. According to the *ergodic theorem*, there is a slight, but finite probability (over an extended period of time) that a thermodynamically *low entropic state* of these broken symmetry field elements may form as a local condensation, within a globally symmetric field, ***S***(k,m)(i)(Hill, 1956). Depending on the intrinsic scalar potential, (Φ)(k,m), of this low entropic and locally asymmetric field, ***L***^(k,m)(i), the physical system will adiabatically expand at a very rapid rate (such as those found in inflationary 'big bang' cosmological models) to restore the overall thermodynamic equilibrium of the globally symmetric state. Since we are unable to rule out the possibility of similar quantum fluctuations at earlier and more globally symmetric states of the physical universe, we are left with the possibility of an *infinite series of exponential adiabatic expansions*, that are known as fractal or eternal inflation by the cosmologist, A. Linde (Linde, 1997).

Let us now turn our attention to the emergence and evolution of matter in galaxies, stars and planetary bodies in our universe. Current cosmological models assume that as the universe expanded in spatial volume, the total amount of energy dispersed within a closed system, allowing for the formation of elementary particles and fields through a series of symmetry breaking phase transitions (Blau and Guth, 1987). However, such a thermodynamically closed model do not, by definition, allow for exchange of energy or matter from sources outside the observable universe. Such exchanges of energy and matter had been incorporated in earlier versions of steady-state cosmological models. Unfortunately, the original rather simple steady-state models proposed by F. Hoyle and his associates have become completely eclipsed by recent successes of the inflationary 'big bang' models, that satisfactorily explains red-shift observations of distant galaxies and the isotropic cosmic black body radiation in the microwave region (Guth and Steinhardt, 1989; Hoyle, 1980). Nevertheless, in view of the multi-universe cosmological model mentioned above, which implies a non-closed system, we may wish to re-examine what happens when we allow energy fluxes to enter our universe under isothermal conditions from external sources. Such considerations lead us to the following intriguing scenario: a *steady-state big-bang cosmological model*, that is not only consistent with current astronomical observations and astrophysical theories, but allows for the existence of a far-from-equilibrium physical system in the universe as a whole. In such a non-linear dynamical system (which itself originated as one among many 'big bang' events), the proposed non-adiabatic, steady-state universe becomes endowed with *self-organizing and stochastic features* that brings about, on the one hand, the stability and ordered structure of matter, and the other hand, the endless novelty and unpredictable outcomes of evolutionary processes (Ott, 1993; Careri, 1984; Prigogine, 1980).

Current cosmological models that incorporate experimental findings in particle physics and predictions from general relativity and quantum field theories have been quite successful in accounting for many recent astronomical observations (Peebles, 1993). However, a number of troubling issues still remain unresolved, not the least of which are satisfactory explanations of intra-galactic dynamics, the formation of galactic clusters and the apparent presence of non-luminous dark matter in a gravitationally closed universe (Rees, 1987). It is now known that gravitational fields (based on observation of luminous matter) become less important at intra-galactic distances, since they are unable to account for the orbital motions of stars in elliptical galaxies, except at relatively short distances from the galactic center (Binney and Tremaine, 1987). Careful red-shift observations of stellar orbital motions in galaxies show almost identical angular velocities (as a function of radial distances to the galactic center) beyond a range of 10 (and up to 100) kiloparsecs (Rubin and Ford, 1970; Faber and Gallagher, 1979, Rubin, et al. 1985). Such identical angular velocities cannot be explained by the known gravitational mass present in the luminous part of galaxies. Based on these and other theoretical considerations, it has been estimated that up to 80 to 90% of physical matter in the universe reside in non-luminous dark matter (Ohanian and Ruffini, 1994; Krauss,1989).

The proposed unified field model outlined above postulates the presence of dark matter particles and fields, based principally on bipolar symmetry principles. It suggests that dark matter particles and fields are non-baryonic and non-leptonic in nature. While the postulated dark matter is a weakly-interacting particle, it has a diminishingly small rest mass. In fact, when observed from the frame of reference of the electromagnetic (photonic) field, it possesses a *negative resting mass*. This is because the resting mass of the locally symmetric photons vanishes (i.e., it is scaled to zero) with respect to the globally symmetric photonic field (special relativity). For these reasons, the photon must necessarily possess a positive and *finite* resting mass when viewed from the reference frame of the dark matter field. At inter-stellar and intra-galactic spatial distances, the postulated dark matter field may nevertheless become a significant interactive factor, that provides a strong cohesive force field to form clusters of stars into galaxies. Thus, galaxies may now be viewed as resembling *rigid bodies*, since stellar objects (as mentioned above) within an elliptical galaxy -- except those in the innermost orbits -- revolve around their galactic center at approximately identical angular velocities, held presumably by the attractive forces of the dark matter fields.

While it appears that dark matter field may overwhelm gravitational attractions at intra- and inter-galactic spatial scale levels, gravitational fields play important roles in the dynamics of binary star motions and in the formation of neutron stars and black holes. In addition, gravitational fields are strongly present in stellar and planetary formations and evolutions. Gravity also maintains the long-term stability of planetary orbits in solar systems, and is inextricably present in all dynamical systems at the terrestrial level. In addition to these static gravitational field effects (reflecting a classical 'action-at-a-distance' phenomenon), general relativity predicts the existence of gravitational waves (or as spin(2) bosonic gravitons in quantum gravity theories). It is currently assumed that such gravitational waves (which have yet to be confirmed empirically) are transmitted at the speed of light. However, based on the above symmetry field model, it has been suggested here that such an assumption (originally derived from special relativity) may no longer be valid. Since the global symmetry of gravitational field, $S_g(\ldots [d]:[d^*], g/g^*, h/h^*, e/e^*, c/c^*, \ldots)$, is greater (or less broken) than the electromagnetic or photonic field, $S_e(\ldots [d]:[d^*], [g]:[g^*], h/h^*, e/e^*, c/c^*, \ldots)$, the characteristic wave velocities of the gravitational field, c_g, may greatly *exceed* the speed of light (in vacuo), c_e. In other words, gravitational waves are transmitted as non-tachyonic, locally field symmetric gravitons, whose transmission velocities are enormously greater than photons, when viewed from the reference frame of the electromagnetic field. Such considerations would also apply to the transmission velocities of dark matter bosons, c_d, with respect to both gravitons and photons, so that $c_d >> c_g >> c_e$. Thus, dark matter fields may possess 'almost instantaneous' weakly interactive effects (i.e., relative to photonic fields) at intra-galactic spatial distances, which would have been entirely ruled out under current constraints of the Lorentz gauge of special relativity. It is interesting to note that while both gravitational and dark matter fields have considerably weak coupling effects when compared to electromagnetic fields at the atomic or molecular scale level, they become increasingly more effective and powerful at astronomical spatial distances.

B. Plasmic, Atomic and Molecular Symmetry Fields:

While the proposed unified field theory above delineated the microscopic symmetry properties (<< 10^{-8} cm) of elementary particles and fields at the cosmological level, such a conceptual approach may be equally applicable to ions, atoms and molecules at both stellar and terrestrial scales. To begin with, symmetry considerations may be usefully employed in describing the physical state of *gaseous plasma*. It is now recognized that the chief constituent of luminous and baryonic matter in the universe is plasmic in nature, since it forms the bulk of stellar and interstellar material and gaseous nebulae (Peratt, 1991; Dendy, 1990). Plasma generally consists of long-ranged global fields of electrically-charged particles (electrons and positive ions) at locally-coherent spatial regimes (i.e., Debye screening distance, λ_D) in the order of 10^{-5} cm to around 10 cm (at electron densities of 10^{14} and 10^{24} per m^3) (Post, 1993). In fact, plasmas exhibit both particle-like behavior that resemble bipolar local symmetries *and* large-scale collective phenomena that resemble globally symmetry fields. In addition, a large variety of plasma wave phenomena have been observed (Parks, 1991; Chen, 1974). They include negatively-charged *electron waves* (such as electrostatic plasma oscillations and electromagnetic light-like waves) and positively-charged *ion waves* (such as electrostatic acoustic and cyclotron waves, and electromagnetic Alfven waves). Thus, plasma field waves are transmitted at propagation velocities ranging from acoustical (10^5 cm/sec) to nearly electromagnetic orders of magnitude (10^{10} cm/sec). It may be concluded that gaseous plasmas are *intermediate states* of low to high density ionized matter that are formed at current energy levels of stellar and interstellar regions of the physical universe[5].

It is believed that formation of long-lived baryonic matter (protons and neutrons) occurred at an early period of the expansion of the universe, leading to the appearance of simple atomic elements, such as hydrogen and helium (Kaufmann, 1994; Longair, 1981). As the temperature of the universe declined, it was the *partial restoration* of local symmetry elements that brought about the creation of stable matter. For instance, if electrons and positrons exclusively combined to restore local electric charge symmetries, the universe would have consisted of *only* globally symmetric electromagnetic or photonic fields (along with very weak gravitational, dark matter and other pre-dark matter fields). That is, the universe would have been essentially 'featureless', containing little or no stable matter. Therefore, it was the coloumbic interaction between negatively-charged *electrons* and the positively-charged *protons* of hydrogen atoms (and their isotopes) that allowed the formation of locally symmetric *and* stable hydrogen molecules. While the symmetry field in the hydrogen molecule is locally restored with respect to electric charges, (c/c^*) (and probably with internal helicity spins, (h/h^*)), protons and neutrons remain asymmetric to color isotopic charges, ($[c]$:$[c^*]$), which are unbroken and remain locally symmetric in leptons (c/c^*). Thus,

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[5] Plasma may also be formed in the cooler regions of earth's upper atmosphere, where the characteristic Debye screening distances, λ_D, are considerably smaller than the average mean distances between ionic particles.

according to the proposed symmetry field model discussed above, protons and neutrons -- consisting of an internal combination q(*u*)and q(*d*) colored and anti-colored quarks -- would have *higher* rest masses than their corresponding leptons, i.e., electrons and neutrinos.

If we next assume that muons and tau-particles (along with their corresponding partner leptons, muon- and tau-neutrinos) are energetically higher *'excited states'* of ground level electrons (and electron-neutrinos), their rest masses would be *less* than the rest masses of 'excited state' baryons formed by a combination of q(*c*), q(*s*), q(*t*), and q(*b*) colored and anti-colored quarks[6]. From the point of view of symmetry breaking and restoration processes as discussed here, the total energy of a locally symmetric or *a*symmetric field must be considerably elevated (e.g, those achieved in particle accelerators) to form 'excited state' baryons, mesons and leptons. While spontaneous breaking of local symmetry fields at low energy levels may occur, it results in the formation of so-called 'virtual' hadrons and leptons with very short-lived fermionic residence times[7]. On the other hand, in super-symmetric quantum field models, all fermions (and their indistinguishable field-mediated bosons) reside in stable massless states at the extremely high energy levels (around 10^{15} and 10^{18} GeV) of the primordial universe (Icke, 1995; Salam, 1989).

An important issue that needs to be addressed at this juncture is as follows: how did the present universe gain an *excess* of negatively-charged electrons, positively-charged protons and left-handed (or chirally *a*symmetric) neutrinos over their counterpart anti-matter particles -- i.e., positively-charged positrons, anti-protons and right-handed neutrinos? In other words, the physical universe appears to be endowed with a highly *asymmetric distribution* of elementary particles. A provisional answer to this question may be stated as follows:

- First, spontaneous breaking and restoration of bipolar symmetries at the local level occurs at *specific rates* in a globally symmetric field. This leads to the 'creation' and 'annihilation' of locally asymmetric 'virtual' particles, whose overall residence time is dependent on the total energy state of the background globally symmetric field.

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[6] Here the symbols q(*u*), q(*d*) q(*c*), q(*s*), q(*t*), and q(*b*) stand for *up, down, charm, strange, top* and *bottom* flavors of quarks -- a nomenclature adopted from the current Standard Model of elementary particles.

[7] The presence of these 'virtual' particles play a minor but very important role in explaining certain low energy phenomenology. The incorporation of their vanishingly short-lived contributions -- reflected as correction factors in a perturbation series in quantum electrodynamic (*QED*) models -- give highly precise theoretical estimates (between one part in 10^4 and 10^9) of the radiative energy splitting of the 2s and 2p electrons in hydrogen atoms (Lamb's shift) and of anomalous magnetic moments in electrons (Mandl and Shaw, 1984).

• Next, stochastic bifurcation events in the primordial universe may allow two or more locally *a*symmetric fields to combine with each other to form relatively stable fermions and bosons within a globally symmetric field. For example, while equal amounts of electrons and positrons are created from the background electromagnetic vacuum state, a slight excess of positively-charged *protons* in the spatial locale of such symmetry breaking events of the photonic field could lead to the formation of locally symmetric 'proton-electron' plasma and atomic fields.

Although the above explanation is partly satisfactory, it leaves one problem disturbingly unresolved: what accounts for the *uniformity* of plasmic, atomic and molecular matter in the observable universe at the present time? In other words, did the seemingly equiprobable and stochastic formation of locally symmetry fields of leptons and baryons exclusively proceed through symmetry restoration of electric charges by electrons and protons only? Or is there in fact a deeper (and as yet hidden) level of *a*symmetries in the electromagnetic and pre-electromagnetic fields that may be responsible for the skewed selection process in the evolution of physical matter in the universe? At the present moment this question cannot be answered on foundational principles, and must await conceptual developments in the future.

C. Symmetry and Asymmetry Fields in Chemical and Biological Systems:

In comparison to the vast bulk of dark matter, plasma and interstellar gases that reside in galaxies and stars, an almost insignificant amount of matter in the universe condensed to form planets and other orbiting bodies in solar systems. Yet, the most interesting and complex forms of chemical substances and living organisms emerged from the evolution of matter on these planetary objects. Moreover, the concept of the *emergent* properties of matter becomes more apparent as we examine the symmetry properties of chemical and biological systems.

In molecular systems, we observe that the formation of locally symmetric fields occurs either as *ionic*, co-ordinate or covalent chemical bonds. For example, in many crystalline materials, ionic bonding occur as locally symmetric electrically-charged attraction between adjacent atoms. In forming covalent bonds in molecules, electrons tend to restore their local (internal) spin symmetries, which are based on Pauli's exclusion principle, that requires the pairing of oppositely spinning electrons (Bader, 1994; Pauling and Wilson, 1935). In quantum mechanical terms, the exclusion principle may be stated as follows: the wave function of any two-electron system is *anti-symmetric* (or spin bipolar) with respect to the electron's spatial coordinates. That is, electrons preferentially pair in their triplet (opposite spin) and not singlet (same spin) eigenfunction states. Thus, the presence of discrete *bipolar symmetries* is clearly a fundamental property of atomic and molecular systems, ranging from the anti-symmetric pairing of electron spins in the (*s*), (*p*), (*d*), and (*f*) electronic shells of atomic elements to the formation of stable ionic and covalent chemical bonds in both simple and complex molecules

While electrons are locally *a*symmetric with respect to electric charges in conducting materials, they are locally symmetric to external spatial rotations at room temperatures. That is, the electric dipole elements in conductors may be rotated in any direction of space without affecting the local *a*symmetry of electric charges. However, if an external globally *a*symmetric magnetic field were to be superimposed on the conductor, the individual electric dipoles will be no longer rotationally symmetric, but will be spatially oriented in a preferential direction. In this manner we induce the formation of a locally *a*symmetric magnetic field in the conducting material[8]. The situation appears to be quite different in super-conducting materials, where the ostensibly 'free' electrons are postulated to be bound together as relatively long-ranged anti-symmetric 'Cooper pairs' (Bardeen, et al., 1957). In this case, the locally and globally symmetric electron fields become indistinguishable from each other in the super-conducting material, allowing for the flow of electric current without ohmic resistance (Leggett, 1989). Thus, in analogy to the transmission of bosonic photons in the electromagnetic field (in its vacuum state), we now have a collective flow of 'massless' electrons, in the form of locally symmetric bosonic 'Cooper pairs', in the super-conductor's globally symmetric field. Moreover, in such a super-conducting state, we are unable to induce internal magnetization of the locally *a*symmetric electric dipoles of the conducting material from an outside magnetic field. In such an experimental set-up, the super-conducting material in fact *repels* the globally *a*symmetric magnetic field, now referred to as the Meissner effect.

There are two other features where terrestrial condensed matter -- i.e., solid, liquid and gases -- have much in common with elementary particle symmetry fields:

(i) A *quantal or discrete distribution of external and internal energies in different spatial degrees of freedom* are present in the *local* symmetry fields of atoms and molecules. In statistical quantum mechanics, this probability distribution is given in terms of molar *partition function*, which is a sum of the relative contributions of translational, vibrational and rotational energies (Chandler, 1987). An illustration of this quantum mechanical phenomena can be seen by examining the heat capacities of a number of mono- and poly-atomic molecules. Experimentally, it has been observed that the heat capacities of gases increases with the number of atoms in the molecule -- e.g., from nearly 3 calories/K for mono-atomic helium, and about 6 calories/K in di-atomic oxygen, to over 10 calories/K for tri-atomic carbon dioxide (at 600 K) (Moore, 1957). This may be explained by recognizing that the additional amount of heat is being internally absorbed in different vibrational and rotational energy states in poly-atomic molecules when compared to the lower degrees of freedom generally found in

[8] This is opposite to the situation where the conductor is a ferro-magnetic substance. In that case, the locally *a*symmetric magnetic dipole moments in the conductor will create an *a*symmetric magnetic field in the surrounding globally symmetric photonic field.

mono-atomic gases[9]. In addition, kinetic energy appears to be absorbed in discrete (or quantal) vibrational and rotatational amounts in gaseous molecules, indicating that poly-atomic molecules at elevated temperatures (or 'excited states') have *increasingly higher* internal degrees of freedoms.

(ii) They have the *capacity of transferring momentum and energy through oscillating wave motions* of atomic and molecular *globally* symmetric fields. The most commonly encountered of these wave motions are those related to acoustical or sound fields. In the gaseous state, acoustical wave motions occur as longitudinal transmission of pressure changes of locally oscillating atoms or molecules (Morse and Ingard, 1968). As is well known, the transmission velocity of sound waves of gaseous materials, consisting of locally symmetric atomic elements or molecules, are considerably less than those of electromagnetic propagations -- by some five orders of magnitude. This may be explained by recognizing that atoms and molecules have significantly lower local field symmetries than to those of photons, when viewed from the reference frame of the globally symmetric electromagnetic (or photonic) field. In more condensed matter medium, such as in solid crystals, acoustical wave motions are generally transmitted as *phonons*, which are discrete or quantal elastic motions of neighboring atoms. As locally symmetric field particles, phonons appear to be analogous to other bosonic particles (such as photons) in its ability to transfer momentum and energy through a globally symmetric lattice field of atomic elements. Moreover, high energy acoustical motions in condensed matter may often exhibit fairly complex wave patterns that are not easily decomposable by Fourier series analysis. This is because these energetic acoustical wave motions tend to be *non-linear composites* of both longitudinal *and* transverse vibrational motions of the locally symmetric ionic or atomic fields (Chaikin and Lubensky, 1995; Jones and March, 1973).

Finally, we shall briefly turn our attention to more complex molecules and macromolecules in biological systems. Most chemical compounds that are present in living organisms have distinctly chiral or optically *a*symmetric features. For example, amino acids are almost universally found as L-isomers (except as D-alanine in bacterial cell walls), while carbohydrates are generally present in their D-isomeric form (e.g., D-glucose in glycosides and D-ribose in nucleic acids) (Kendrew, 1994; Abeles, et al., 1992). Naturally occurring polynucleotides, such as plant and animal DNAs, are generally found as double-stranded right-handed α-helix (in both its A and B forms) and as a left-handed helix (Z form). While it is not entirely clear which DNA conformation predominates when placed in an aqueous medium, it is believed that *in vitro* they remain in dynamic equilibria with each other. On the other hand, most DNA in chromosomal genomes of intact cells in living organisms are

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[9] It should be noted that the heat capacities of mono-atomic gases *do not* increase with elevation of temperatures, indicating that they *only* possess translational degrees of freedom.

believed to exist chiefly in their right-handed α-helical B form (Kendrew, 1994).

An important question now arises: what accounts for frequency of spatial *a*symmetries of chemical substances that are found in the biological world? To answer this question, let us imagine a biological world without any form of molecular *a*symmetries built into them in the first place. For example, if amino acids were biologically formed as a racemic mixture of equal amounts of L- and D-isomers, it would result in the synthesis of two different types of protein molecules that were essentially complex mirror images of each other. This would immediately pose a serious problem in the biological world, since cellular enzymes that catalyze metabolic reactions are chiefly composed of protein molecules (except for the presence of metal ions and other low molecular weight co-factors). Hence, biological organisms would be able to utilize such racemically synthesized amino acids only half the time, creating unnecessary waste and loss of efficiency. Additionally, there would be the awkward problem of utilizing amino acids in the overall food chain. Unlike bacterial species, most eukaryotic organisms (including humans) require the assimilation of exogenous amino acids in their diet. All these problems would be simply solved by having a *unique isomeric form* of amino acid, which assures the universal availability of dietary amino acids for all biological species that evolved on earth. The above reasoning could equally well be extended to carbohydrates, nucleic acids, fatty acids and other essential biochemical substances. It would therefore appear that a necessary pre-requisite for establishing and maintaining a viable biological system is through *selectively biasing* the synthesis and distribution of chiral and isomeric organic compounds.

In addition to the formation of molecular *a*symmetries, other forms of symmetry breaking processes have occurred at the cellular and organismic level in the course of biological evolution of species. Prokaryotic species, such as bacteria, are haploids in their genetic make-up, i.e., they contain single strands of chromosomes in each cell nucleus (Meyers, 1995). However, all eukaryotic organisms are by definition genetically diploids, which means that they contain a pair of chromosomes in each cell nucleus. In haploidic species, reproduction of daughter cells occurs by asexual cloning of individual cells. On the other hand, in diploidic species, reproduction is carried out by the sexual union of individual chromosomal strands that were contributed separately by each parent's germ cell line. It would seem that in evolving from haploidic to diploidic species, reproductively complementary sexes came into existence in the biological world. Thus, the introduction of sexual reproduction may be viewed as a biological form of symmetry breaking event -- from a single (*a*sexual) locally symmetric cell line to bipolar (or *bi*sexual) locally *a*symmetric cell lines.

At present, the predominant paradigm of biological evolution is the neo-Darwinian model of natural selection of adaptive species. This model accepts the underlying premise that favorable phenotypic traits arise principally by random and step-wise mutations on the DNA molecule, which encode biochemically significant information on individual genotypes of each species (Mayr and Provine, 1983; Maynard Smith, 1982; Mayr, 1976; Dobzhansky, 1970; Williams, 1966; Simpson, 1953). There are, however, a number of outstanding process-related and mechanistic issues that remain controversial and have not been satisfactorily resolved at the present moment. These issues may be summarized as follow:

- *The rates of biological speciation and extinction*: Based on an analysis of paleontological fossil remains, there appears to be periods of rapid proliferation and extinction of species, that seems to contradict the concept of gradual speciation in the current neo-Darwinian model. To account for this puzzling phenomena, it has been suggested that biological 'saltation' or sudden increase in mutation rates may have occurred in earth's geological history (Gould and Eldridge, 1993). This period of rapid species proliferation was then followed by extended periods of gradual or more normal rates of genetic mutations and speciation. While such a theory of 'punctuated equilibria' may account epigentically for large losses of species (e.g., due to sudden loss of earth's protective ozone layer), it is not altogether clear how non-genetic processes could explain rapid rates of speciation.

- *Group versus individual selection of species*: For the most part, evolutionary biologists and population geneticists today believe that natural selection occurs in discrete steps (or quantally) through genetic mutations on *individual* members of a species (Dawkins, 1989; Williams, 1971). Accordingly, phenotypic adaptations of species may be described and accounted for by a linear superposition (or a summed average) of different individual genetic traits. However, a number of biologists have challenged such a restricted point of view and have suggested that natural selection of species also occurs by interactive *group* adaptation of genetic and phenotypic traits (Wilson, 1980; Wynne-Edwards, 1971; Wright, 1945). An open question here is whether such a supra-genetic process may also occur through collective feed-backs and non-linear interactions of different species occupying similar ecological niches and food webs.

- *Genetic drift and neutral selection*: In recent years there has been accumulating evidence to show that non-harmful and potentially favorable genetic mutations may occur that do not get immediately selected or rejected, but may remain inheritable in its latent or dormant form for long periods in the life history of a species (Crow, 1987; Kimura, 1983). This concept of genetic drift or a 'neutral' selection process, which expresses itself in the delayed selection of adaptive phenotypic traits, raises the following question: to what extent and at what rate does biological evolution occur through such a natural selection mechanism? A corollary question is whether 'neutral' selection confers a net benefit or detriment to the biological evolution process itself, since both potentially adaptive or ill-adaptive mutations are presumably present in the individual genotype of a species. It is apparent that the proponents of the genetic drift hypothesis, who claim it to be the predominant means of biological evolution, must demonstrate conclusively that both rapid and normal rates of speciation proceeds through prior retention of genetically mutated traits.

• *Programmed versus self-organizing selection processes*: Current models of biological evolution are firmly based on deterministic principles of classical mechanics, while at same time allowing for chance and randomness to occur in the natural selection of biological species (Monod, 1971). However, the current Neo-Darwinian model (by itself) is unable to address whether there is a pre-determined biological teleology (or teleonomy) that accounts for the seemingly endless proliferation of living organisms on earth (Mayr, 1976; Lewontin, 1971; Teilhard de Chardin, 1965). An alternative hypothesis has been proposed that suggests that evolution of biological species is a self-organizing process in an energetically open system (Kauffman, 1993; Careri, 1984). In such a non-linear steady-state system, the process of biological evolution is essentially stochastic and proceeds without simple reductionistic or programmed genetic algorithms. While the above model has a number of attractive features, especially as it takes into account the far-from-equilibrium and low entropic nature of biological systems, it remains to be seen whether it can also address the unresolved evolutionary questions that were discussed earlier.

IV. CONCLUDING REMARKS:

In this paper we have introduced a number of novel and at times radical concepts that are not necessarily part of the current paradigm in the natural sciences. Some of these hypotheses and ideas were explicitly stated, but others were only indirectly alluded to, so that their full significance had not been fully analyzed or explored. In the concluding segment of this paper we shall summarize the underlying basis and meanings of these concepts, so that the reader may examine whether they have any intrinsic merit. By necessity, some of these ideas are rather provisional and have been only partially developed. It would indeed be gratifying if others were to pick up what is being presented here with the view to demonstrate or extend their theoretical feasibility in a more rigorous manner or by designing empirical means to see if the postulates and predictions offered here have any basis in physical reality.

We shall first attempt to re-capitulate what was discussed above and present its main findings. Hopefully, we shall then be in a position to address the central question of this paper: how did the physical, chemical and biological universe emerge from its primordial past and evolve into the world in which we find ourselves today? Since much of the earlier sections of the paper were rather abstract and filled with technical details, it would preferable to examine the conceptual principles and ideas we have covered thus far in somewhat simpler language:

• It was postulated that the primordial vacuum state of the universe was in a state of high global and local field symmetries. Each symmetry field was composed of bipolar elements, which remained both globally and locally symmetric, until external conditions allowed the spontaneous breaking of local symmetries. At any given moment, there is a continuous process of local symmetry breaking and restoration, whose dynamic interplay leads to the formation of scalar and vector potentials, and for 'mass' and inertial forces to arise in locally *a*symmetric fields within a larger globally symmetric field.

• A comprehensive unified field theory was presented that postulated the existence of a nested hierarchy of globally and locally symmetric and *a*symmetric fields. It was suggested that the present observable physical universe arose out of a thermodynamic unstable and low entropic state, that led to a series of phase transitions of decreasingly globally symmetric fields -- pre-dark matter, dark matter, gravitational, helicity spin-charge, electric-charge and color-charge fields. The combination of these locally *a*symmetric field elements created the current family of stable fermions and bosons in the physical universe.

• It was shown that symmetry breaking and restoration processes not only occurred in the physical universe of elementary particles and fields, but they were also found in more complex chemical and biological systems. The emergence of plasmic, atomic and molecular symmetry fields occurred by a series of symmetry breaking phase transitions, whereby new properties of physical matter arose that were *analogous but not self-similar* to elementary particles and fields. Biological systems emerged in a completely unexpected or stochastic manner, which now consists of a wide variety of *a*symmetrical chemical constituents and bisexual organisms. Such energetically open living systems were also characterized by its low entropic state, which led to the seemingly endless and rich proliferation and evolution of biological species.

Let us now examine the proposed unified field model, that was based on the propositions of an axiomatic symmetry field theory. To begin with, the total energy of the primordial vacuum -- i.e., in its asymptotically-maximum globally symmetrical state -- resides entirely in its *rotational degrees of freedom*, that are present in a hierarchical series of bipolar spin elements of the global and local symmetry fields. In other words, we propose that the internal angular momenta or spin states of each symmetry field element are the ultimate *repository* of the vast potential energies that are intrinsically present in the primordial vacuum state. Thus, such a vacuum state would be characterized by a singular scalar potential, which after breakage of its global field symmetry would be expressed by an additional set of vector potentials. In this manner, each subsequent transformation of globally symmetric to *a*symmetric fields would be characterized by a series of field-specific scalar and vector potentials. For example, the relativistic electromagnetic field is currently described in quantum field theory models by one scalar and three vector potentials.

It should be recognized that in this paper we have employed the definition of symmetry fields in its most liberal and extended sense. Strictly speaking, the concept of a field is a purely *abstract notion* and as such has no intrinsic basis in any 'real' physical system. For example, in fluid mechanics, we treat liquids and gases as if they were a continuous media, despite realizing that they consists of discrete atoms or molecules[10]. Similarly, we have conventionally treated acoustical, electromagnetic and gravitational effects as field phenomena. However, today we recognize that acoustical or sound effects are essentially quasi-field phenomena. This is because their wave motions are believed to be oscillatory (or elastic) motions of a discontinuous media through which they are propagated, that consists of discrete atomic or molecular constituents. On the other hand, electromagnetic and gravitational fields are still seen as classical field phenomena. However, in quantum mechanics, the transmitting boson of the electromagnetic field, the photon, is described as a point particle, in much the same manner as other bosons or fermions. In the proposed unified field model, we have retained the particulate nature of the photon as discrete bosons of the electromagnetic field. But in addition, we have described the electromagnetic field as being equivalent to a globally symmetric photonic field, which consists of a *discontinuous array* of locally symmetric bosonic photons. In other words, the photonic field is now conceived as a 'discontinuum', that is equivalent to a globally symmetric fluid-like medium containing locally symmetric photonic fields[11].

Several important features of the proposed unified field theory, which were not fully explored or presented earlier, may now be briefly stated as follows:

- The *concepts of space and time* in the proposed model is viewed from a completely different perspective from those that are currently accepted in the natural sciences. To begin with, the use of spatial and temporal dimensions in relativity theory and quantum field theory are *frame-dependent*, in this case to the global symmetries of the Lorentz gauge. In relativistic mechanics, space and time are measured by retaining the invariance of Lorentz transform equations, which had originally been derived with respect to the electromagnetic field only -- i.e., by postulating that the velocity of light propagation (in vacuo) is *constant* to all kinematic frames of references. What is not currently appreciated by most natural scientists is that one could construct similar relativistic transform equations for *any* field phenomena. For example, an acoustical or phononic version of a relativistic 'Lorentz' equation may be derived by maintaining the invariance of the rate of transmission of sound or elastic wave motions. In this case all spatial and temporal measurements would *only* be made with respect to the

[10] This is often done for mathematical elegance or computational ease, since we can more easily derive analytical or numerical solutions for the equations of motion of fluids in its simpler differential or integral form than in its more realistic (and thus more cumbersome) difference equations or summation series.

[11] It is obvious that the concept of the field cannot be taken literally, since the 'field' has the apparent property of being 'continuous' only when viewed from an external or 'macroscopic' reference frame, but not when referred to an internal or 'microscopic' frame.

acoustical or phononic field[12]. In addition, the equations of motions and action integrals in quantum field theories are derived by 'second quantization' of the field, which implicitly brings in Planck's constant, which is a fundamental invariant parameter of the electromagnetic or photonic field. Thus, it appears that *both relativity theory and quantum mechanics do not reflect universal physical laws, but are uniquely and exquisitely derived for a world in which spatial and temporal measurements were made almost exclusively by visual observations*.

• While the proposed unified field model have many features in common with present quantum field theories, there are a number of *conceptual and interpretative differences* that should be noted. The proposed unified field theory is a general extension of relativistic quantum mechanics that originated in the derivation of Dirac's wave equation for fermionic particles[13]. Since we employed the concept of bipolar (or reflection) symmetries in the proposed model, we have avoided the use of continuous or Lie group symmetries, such as unitary SU(N) or orthogonal SO(N) symmetry groups. In these non-discrete symmetry groups, the complex or real components of the rotational operator are transformed in internal abstract spaces or isospin states, either at the global or local level. With locally-based symmetries, we may construct gauge-invariant (or Yang-Mills) models, which for example turned out to be highly successful in developing a renormalizable electromagnetic-weak force field theory. In contrast, the proposed unified field model is entirely conceptual at this stage of development, but has the advantage of being simpler and intuitively more accessible for future quantitative developments. Hopefully, the proposed model may prove to have all the internal quantum 'charge' symmetries that are currently embedded in higher Lie symmetry groups, and yet allow the inclusion of new symmetry fields that have not been postulated or even suspected by others at the present time.

• Although the *concept of mass or inertia* in the proposed unified field model is an innovative and seemingly arbitrary proposal, it is *consistent* with the conceptual foundations of Mach's principle. To begin with, in the proposed model, the notion of

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[12] This is illustrated by the following example: in a world consisting of only blind human beings, spatial and temporal measurements may be primarily carried out by use of sound waves. Thus, assuming that the velocity of sound remains constant, all kinematic measurements of physical events that approach the speed of sound (with respect to a stationary blind observer) would necessarily be subject to an *acoustical relativistic* effect.

[13] In avoiding the difficult conceptual problems of the second-order Klein-Gordon equation -- that were associated with negative probability and energy states -- Dirac derived an alternate *relativistic* equation of motion for electrons. He did so by eliminating negative probabilities by imposing additional rotational degrees of freedom, and thus *only* retained the solution for negative energies. He later equated these negative energy states to the existence of *anti-matter particles*, the positively-charged positron.

a resting mass is no longer left undefined (as is the case in both classical and quantum mechanics), but is viewed as the *relative resistance* or inertia that is encountered when locally *a*symmetric fields are spatially displaced with respect to the globally symmetric field. For these reasons, there is little reason to invoke some type of hypothetical Higgs mechanism to confer resting masses to the electro-weak vector bosons. In a similar manner, the higher resting masses of both ground level and 'excited state' hadrons may be understood by recognizing the greater degree of local *a*symmetries they possess in comparison to leptons, when viewed from the reference frame of the globally symmetric electromagnetic (or photonic) field. Its consistency with Mach's principle may be seen as follows: as in all quantum field theories, the proposed model also incorporates the notion of second, third, and higher order interactions (in a perturbation series) for describing the equations of motion of locally symmetric fields against the background global field. Since these field interactions and vacuum polarizations bring about the creation of dynamic forces and 'virtual particles' into existence, they become by definition the total inertial interaction of matter in the physical universe. In essence, this is the *underlying basis* of Mach's principle: everything interacts inertially with everything else, no matter how weakly coupled or far removed they are from one another in the universe.

- Intimately related to the notions of mass and inertia in the proposed unified field model is the *concept of characteristic wave velocities* of each globally symmetric field. We have shown that bosons, such as photons, are massless because they are locally symmetric with respect to the globally symmetric photonic field. They are therefore spatially displaced or propagated by a characteristic wave velocity that remains *invariant* in the background electromagnetic vacuum state. In the same manner, we may now define invariant characteristic wave velocities for the dark matter, gravitational, helicity spin (i.e., neutrino), color-gluon, plasmic, atomic and molecular fields. In many instances, there may be a large variety of sub-set fields, such as with plasmic and acoustical waves that are formed in different states of ion-electron and electron-nucleon combinations. A question that immediately arises is what determines the characteristic wave velocities of each bosonic symmetry field. This may be answered as follows: from the point of view of the gravitational field, the photon has a *finite rest mass*, since it is locally *a*symmetric with respect to the globally symmetric gravitonic field. For these reasons, electromagnetic field transmissions are not 'instantaneous' but possess a finite upper limiting wave velocity. Using the same set of reasoning we may understand why neutrinos must have a small, but finite mass and why acoustical or sound waves (as phonons) have considerably lower velocities of transmissions than photons. On the other hand, the proposed unified field model clearly suggests that *gravitational field waves travel at propagation velocities that are considerably greater than light waves.* This latter heuristic point of view needs to empirically verified, since it *apparently contradicts* the foundational propositions and causal framework of special relativity.

• While, in principle, there may be an infinite number of symmetrical field states in the physical universe, we have thus far identified a *limited number* of globally and locally bipolar symmetry fields. These postulated symmetry fields not only account for the present family of observed or proposed fermions and bosons, it can accommodate the existence of additional, as yet unknown *dark matter particles and fields*. Suffice to say that these dark matter symmetry fields and their corresponding bosons and fermions have not been experimentally observed at the present moment. However, based on recent astrophysical observations of orbital motions of stars in elliptical galaxies, there is indirect, but strong empirical reasons to believe that such dark matter particles do exists in large amounts in the intra- and intergalactic regions of the physical universe. In contrast to current cold and hot dark matter theories, in the proposed unified field model, dark matter are not seen as exotic, non-luminous massive particles with strong gravitational field content, but *are entirely different locally symmetric field particles that exert weakly-coupled but extremely long-ranged field effects that are not gravitational in origin.* Moreover, in the proposed model, dark matter particles and fields (along with other primordial pre-dark matter fields) are postulated to exist without the need for additional *ad hoc* assumptions or hypotheses. If the proposed model has any validity, then it is possible that dark matter permeates all regions of the universe and its bosonic particles travel at unimaginably high velocities so that *all regions of the universe may be causally linked by a diminishingly weak but finite force field almost instantaneously.* Based on current technologies, there is little likelihood that this theoretical finding could be tested in the foreseeable future.

• One interesting consequence of the proposed unified field model is the possibility that global symmetry breaking events at the cosmological scale -- i.e., during its hyper-inflationary phase -- could have initially led to the formation of primordial *'proto-galaxies'*,composed primarily of pre-dark and dark matter particles and fields. 'Proto-galaxies' may be viewed as localized regions of low entropy, which along with further energy dispersion and spatial expansion of the universe, led to the formation of galactic clusters composed of individual galaxies, which form the stars and planetary bodies of our observable universe. The proposed model suggests that such a cosmological dynamical process may have occurred through a series of *phase transitions at localized regions of low entropies*, that consisted of a nested hierarchy of increasingly broken local and global field symmetries. In such a scenario, the primordial universe consisted mainly of pre-dark and dark matter, followed by the formation of the gravitational field, which together formed the basis of proto-galactic and galactic clusters. Thus, only at later period of time do we see the emergence and formation of "globally *a*symmetric" electromagnetic, weak and strong fields. In sum, the proposed model is quite consistent with a 'modified' version (i.e., incorporating dark matter fields) of current hyper-inflationary 'big bang' models, which have been recently proposed by elementary particle cosmologists (A. Linde, 1997, 1990).

• The proposed unified field model leads to another interesting and probably inevitable conclusion -- the possibility that there are *parallel universes*, or that there are *multiple smaller universes* that grew out of thermodynamically unstable and low entropic regions of a larger universe. It is possible that we may have to redefine once again what we mean by the term 'universe'. In recent years, without much fanfare or intellectual resistance, we have had to expand our astronomical horizons, because we had become aware that the observable universe is not what we had thought it to be. For instance, in the past we had defined the universe as the sum content of our Milky Way with its billions of stars; today we recognize that there are in fact billions of galaxies, each the size of our home galaxy, that range spatially and temporally to the outer fringes of the observable universe. While it may well turn out that the collection of current galaxies -- that constitute our one and only universe -- originated some 10 to 20 billion years ago in the so-called inflationary 'big bang', this may not be the total extent of a yet larger universe. Though such a 'super-universe' or a cluster of multi-universes may in fact exist, for all practical purposes, it is out of our range of observation at the present moment.

In the last segment of the paper, we had briefly looked at the emergence of the chemical and biological world through a series of symmetry breaking events at the atomic and molecular level. However, *it is fair to state that understanding the origin and evolution of living organisms is one of the most difficult problems that the natural science community is faced with today.* Biological systems are inherently complex and exhibit features that are significantly different from most elementary particle, atomic or molecular field interactions. Therefore, they are not reducible to a simple extrapolation from the physical/chemical to the biological world. Yet there are intrepid scientists who make such reductionist extrapolations from time to time, probably because they believe in the innate worth of carrying out such intellectually demanding exercises. We have resisted this temptation here, except to point out some interesting broken symmetries and *a*symmetries in biological systems, and have left further developments in this research area to other investigators more intimately acquainted with the living world.

In conclusion, we have attempted in this paper to clarify conceptual issues and unresolved problems in the physical sciences, with brief forays into the chemical and biological world. Along the way we have stumbled upon or made a few discoveries that may appear on first acquaintance to be rather strange and unfamiliar, since they do not fit our current scientific paradigm. However, the proposed unified field theory was developed as a conceptual framework of a model universe, where the intrinsic beauty of symmetry and symmetry breaking principles served as its foundational basis. To quote P. Dirac on this point: "It is more important to have beauty in one's equations than to have them fit experiment . . . because the discrepancy may be due to minor features that are not properly taken into account that will get cleared up with further developments of the theory." It is hoped that with such a faithful guide on our side, a quantitatively more detailed unified field theory will be developed in the future.

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