White Paper XIX

Towards Understanding the Internal Symmetries of Nature: Gauge Symmetry States

by

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An Executive Synopsis on Gauge Theory

Gauge Theory development has probably been the most important advance of orthodox physics in the past 50 years. It deals with the interaction of **external** fields with **internal** symmetry states in nature.

It deals with the dynamic movement, in phase space, of the electron wave function phase angle, θ, say, with respect to the absence or presence of the details of an external field and the particular Gauge symmetry state the electron may occupy. This is dependent upon fiber bundle mathematics and group theory considerations leading to a unique locus of the particle's phase angle, θ, at each (x,y,z,t) point in spacetime. Our normal macroscopic physical reality exists in a U(1) Gauge symmetry state because it involves only one type of relevant particle, the electron whose phase angle, θ, moves in a planar ring in phase space. The SU(2) Gauge state involves two relevant phase angles, θ and ϕ, which move in a three-dimensional sphere in space at each (x,y,z,t) point. For SU(n) Gauge states, n^2-1 parameters are involved in the relevant interaction so that, for n = 2, three parameters are critically involved. For a neutron/proton exchange reaction, this is an SU(2) gauge state with the neutrino as the third parameter. In the case of an electron/magnetic monopole interaction to produce an SU(2) Gauge state, what I have labeled a "deltron" is the necessary third parameter to stabilize this particular symmetry state. Loss of the deltron from this complex leads to "symmetry breaking" and transition to a U(1) Gauge state for the electron plus a different U(1) Gauge state for the magnetic monopole (but undetectable to our spacetime instrumentation).

Introduction

Today's establishment science, as wonderful as it is with Quantum Mechanics (QM) and Relativistic Mechanics (RM), utilized a distance-time-**only** Reference Frame (RF) for its "outward-looking" (Logos) investigation of nature. With respect to this RF, it seeks internal self-consistency of all experimentally discovered data and denies viability to **any** experimental data that is inconsistent with this absolute measurement stick. This judgment has been maintained for the past 400 years and that choice is perfectly valid provided nature expresses itself **only** via a distance-time-dependent class of phenomena.

However, we should all agree that there is at least one other class of phenomena operating in nature that are **not** distance-dependent. This class of real phenomena includes human consciousness, intention, emotion, mind, love, etc. This class of experimental data appears to require an "inward looking" (Mythos) type of RF to make internally self-consistent sense of the gathered experimental data with respect to today's distance-time-only RF.

This issue, in today's world, is compounded by the fact that, in humans and probably in at least all vertebrates, both of these classes of natural phenomena function in the same individual organism. Thus, to ultimately understand such biological organisms at a mathematically quantitative level, an entirely new RF must be conceptually created and mathematically formulated so that biophysicists, bioengineers and biologists in general, not to mention psychologists, psychiatrist and medical practitioners, can meaningfully address this complex issue.

A decade or so ago, this author formulated such a new RF that has the capability of seriously addressing this scientific and human problem(1). This new RF is a duplex RF consisting of two, **reciprocal**, four-dimensional sub-spaces, one of which is distance-time. All of our present orthodox science utilizes the distance-time subspace for its mathematical expressions. All of the consciousness-related and higher-dimensional-related aspects of nature will eventually utilize the reciprocal domain aspects of this RF for its mathematical expressions. Further, a coupling medium is needed to act between the substances of these two subspaces so that they can actually interact with each other. The study of these coupled state processes has been labeled "Psychoenergetic Science"(2).

Over much of the past century, Gauge Theory has emerged as one of the most significant and far-reaching developments in new physics developed by humankind with potential areas of application that extended far beyond elementary particle physics(3). Gauge Theory represents a new synthesis of Quantum Mechanics (QM) and symmetry. It allows us to understand how the fundamental forces of nature can be unified within a single coherent theory that introduces a novel, new element into our understanding of symmetry. Although I will briefly lay out the necessary new concept immediately, its foundation for deep understanding must be laid before we return to its application to the future development of humans. There are three layers of background needed, which I will try to simplify as much as possible. These are: (A) vectors, tensors and matrices, (B) external symmetries and group theory and (C) internal symmetries and Gauge Theory. This author will attempt to make this information "user-friendly" for the general reader. However, for the serious student, much follow-up study will be required.

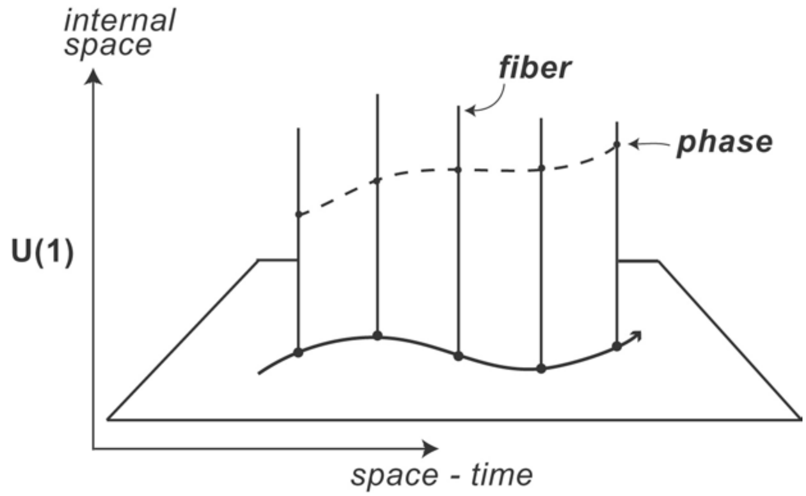


Figure 1. Geometrical picture of the internal symmetry space. Space-time is the horizontal plane and the internal space direction is specified by phase angles in the internal space or “fiber”.

The New Concept[3]**:** The geometrical structure of Gauge Theory can be illustrated via the very convenient and intuitive picture presented in Figure 1. Here, the **external** space (distance-time) reference frame (RF) is represented by the horizontal plane in Figure 1 and the **internal** symmetry space is drawn vertically at each point. A vertical line in the figure depicts the case of a one-dimensional internal space like that of the U(1) group (our normal macroscopic electromagnetic world designation). This internal space is called a “fiber” by mathematicians. In this picture, the spatial location of a particle is given by **a coordinate point** in the horizontal plane while the orientation in the internal space is specified by angular coordinates in the “fiber” space. As the particle moves through space-time, it also traces out a path in the internal space above the space-time trajectory (see “phase” in Figure 1). When there is **no** external Gauge potential (a specific thermodynamic potential in general – but for a U(1) Gauge symmetry space it is usually an electromagnetic (EM) potential), the internal space path is completely arbitrary (the angle, θ, in Figure 2 representing the phase angle of the electron wave function, hops around without constraint).

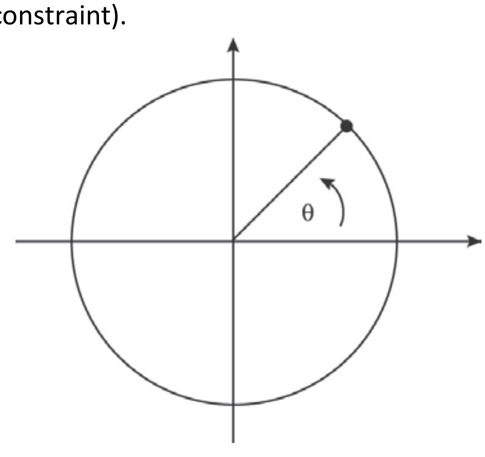


Figure 2. The internal phase of the U(1) Gauge group of electromagnetism. The phase θ defines an angular coordinate in the internal symmetry space.

When the particle interacts with an **external Gauge field**, the path of θ in the internal space of Figure 1 is a continuous curve determined by this Gauge potential.

The idea of using a Gauge potential to "marry" together space-time with an internal symmetry space is a relatively new concept in physics. In mathematical jargon, the new space formed by the union of four-dimensional space-time with an internal space is called a "fiber bundle" space. The reason for this name is that the internal space (or fibers) at each space-time point can be viewed as the same space because they can be transformed into each other by a Gauge transformation[3]. The internal phase angle, θ, for the U(1) group (see Figure 3) of EM is constrained to move within a circle (see Figure 2) at every space-time point.

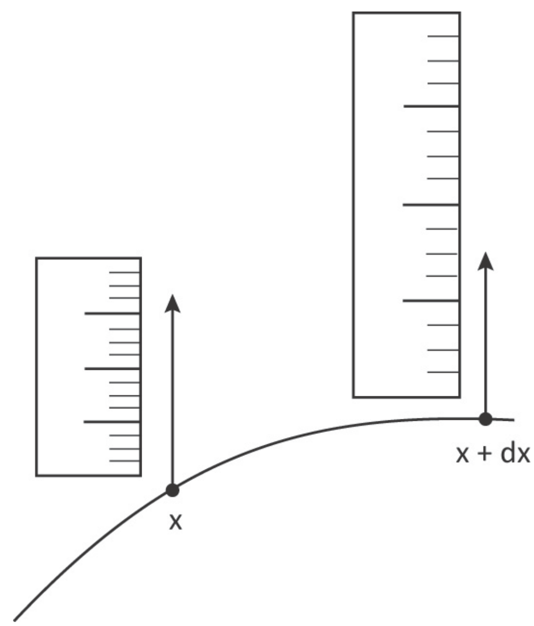


Figure 3. The scale factor S(x) in Weyl's Gauge Theory is illustrated by the change in length of a metre stick from position x to x + dx.

However, for the higher dimensional SU(2) group, because we now have two different and independent internal phase angles, θ and ϕ, to deal with, it is necessary to attach a sphere at each space-time point (see Figure 4)[3,4].

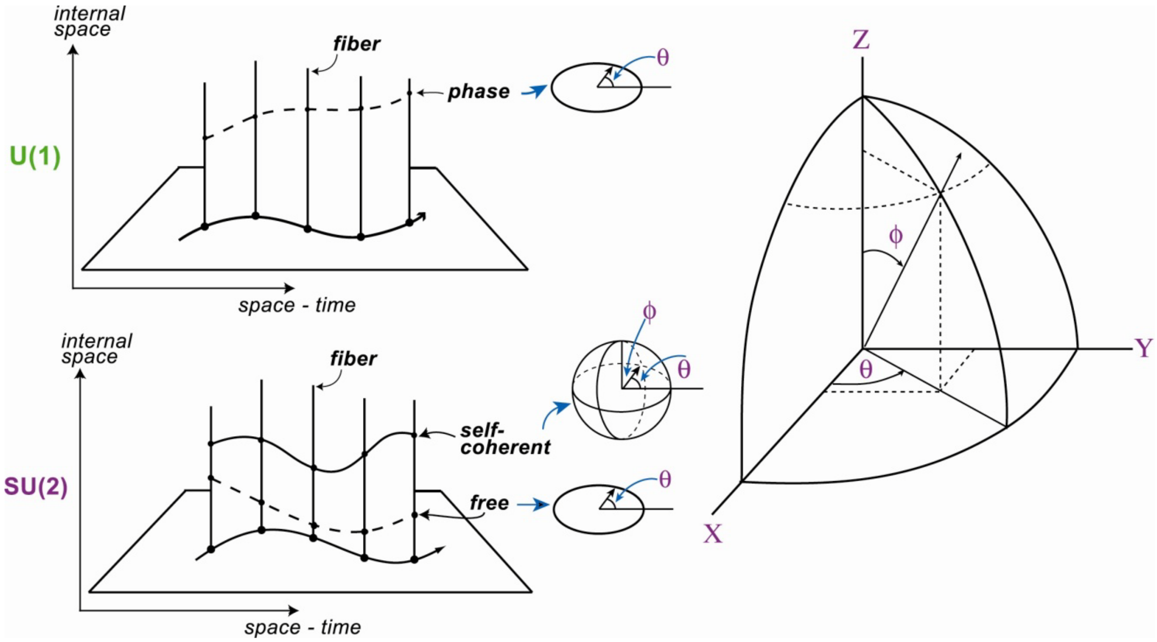


Figure 4. Illustrations crucial to meaning articulation or the U(1) and SU(2) EM Gauge symmetry states.

Essential Technical Background

A. **<u>Scalars, Vectors, Tensors and Matrices/Determinants:</u>** In a physics description of distance-time nature, we are accustomed to dealing with both extrinsic thermodynamic variables that govern the overall behavior of outer nature and the intrinsic properties of materials from a distance-time perspective. These variables and properties all attempt to characterize a quality or qualities of a particular material in **this** RF for viewing nature. These qualities can be thought of as being members of four different classes:

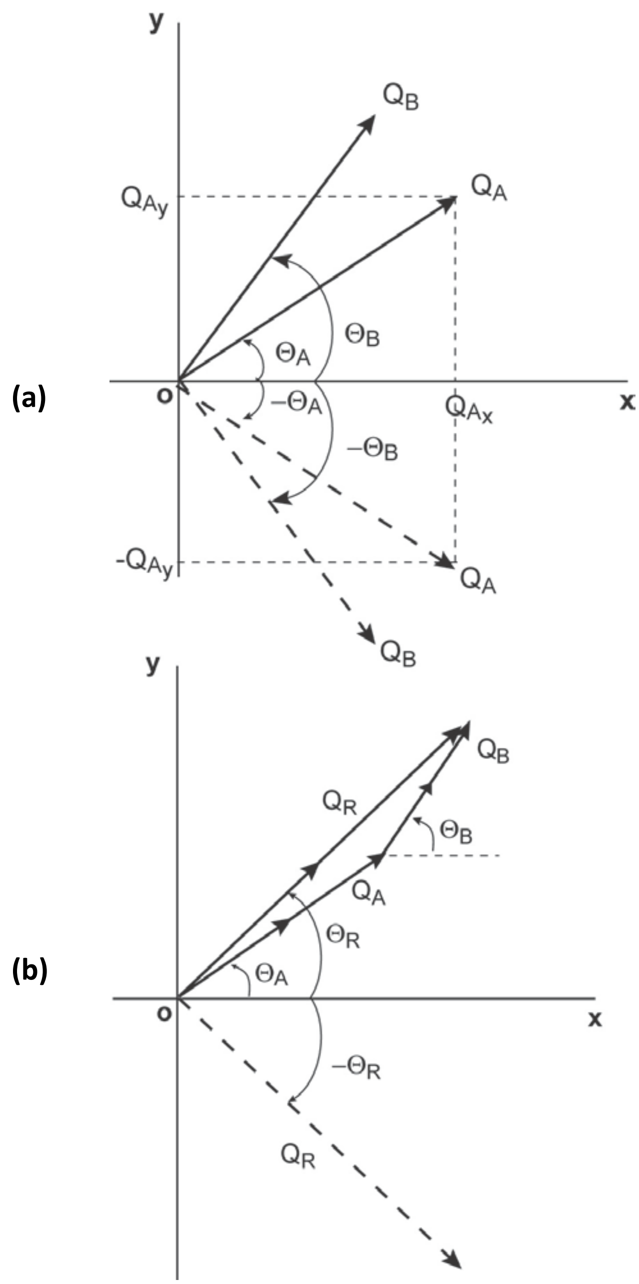
(1) <u>Scalar Qualities</u> such as temperature, pressure, concentration or density may vary from point to point but, at any given point, are not also connected with direction around that point. Such non-directional qualities are called **scalars** and we note that the value of a scalar is completely specified via a single number denoting magnitude. A scalar is also called a **tensor of zero rank.**

(2) <u>Vector Qualities</u> such as mechanical force, electric field, magnetic field, gravitational field, etc, require the use of three numbers (or four numbers for relativistic spacetime) at a point for complete specification. One of these numbers is the vector magnitude while the other two (or three) are directions from that point relative to some frame of reference (RF). Thus, the magnitude of such a quality at a point varies with direction around that point. If we define our spatial RF at a point using the standard (x,y,z) coordinate designation, then the three components (<u>Ex</u>, <u>Ey</u>, <u>Ez</u>), are needed to define the electric field vector, <u>E</u>, at a point. A vector is also called a tensor of first rank.

Figure 5.

Phasor diagrams for rotating vectors.

This is an extremely important and subtle point in our normal physical reality, called the EM state. Many of the important qualities of interest are vectors and thus, for a system of multiple parts, there is always an **information entanglement between the parts** unless they are **totally** isolated from each other.



As a two-dimensional example, Figure 5a illustrates two vectors Q_A and Q_B, positioned in the xy plane with origin at the point zero and phase angles θ_A and θ_B relative to the x-axis, respectively, with positive y-component. This is called a phasor diagram ($Q_A = R_A \exp(i\theta_A)$, $Q_B = R_B \exp(i\theta_B)$) for the two vectors where R_A and R_B are the vector magnitudes, respectively. The dashed vectors, below the horizontal line in Figure 5a show what is called the **complex conjugate** of these two vectors Q_A and Q_B. These two new vectors have the same magnitude, R_A and R_B, but have phase angles of opposite sign, $-\theta_A$ and $-\theta_B$. One important point to note here is that the mathematical product of a vector (Q_A, say) and its complex conjugate (Q^*_A) yields the amplitude squared, R^2_A. This is just the intensity, I_A, which is all that one can measure experimentally.

In Figure 5b, the sum of these two vectors, $Q_A + Q_B$, is shown to lead to the resultant vector, Q_R. The procedure of vector summation is to draw the two vectors in a head to tail arrangement so that the head of Q_A touches the tail of the vector of Q_B. The resultant vector, Q_R, is just the arrow joining the **tail** of Q_A to the **head** of Q_B in Figure 5b so that it has magnitude, Q_R, and phase angle, θ_R. Thus, the resultant's intensity pattern, I_R, is just R^2_R, obtained by multiplying Q_R by Q^*_R.

Although the magnitude of the resultant wave amplitude $|Q_R| = R_R$, is an important quantity, it is the resultant intensity pattern, $I_R = R^2_R$, that is most important because it can be experimentally measured. Using Figure 5b and the Pythagorean Theorem (for a right-angle triangle, the square of the hypotenuse is equal to the sum of the squares of the other two sides) we have, via some simple algebra,

$$Q_R^2 = Q_{R_x}^2 + Q_{R_y}^2 = [Q_A^2 + Q_B^2] + 2\left\{Q_{A_y} Q_{B_x} + Q_{A_x} Q_{B_y}\right\} \qquad \text{(A.1a)}$$

$$= [Q_A^2 + Q_B^2] + 2R_A R_B \cos(\theta_A - \theta_B) \qquad \text{(A.1b)}$$

and cos means the cosine function. The sum of the first two terms in Equation A.1b is exactly what we would have if we didn't need to treat A and B as vectors but could treat them just as scalars. However, because here they must be treated mathematically as vectors, we must include the second term on the right in Equation A.1b. This term always represents an **information entanglement** between these two vectors. Whenever one is dealing with a **system's event**, where each of the key interacting elements must be treated as a vector instead of a scalar, this type of **information entanglement** is always present in the mathematical treatment. A classical example of this type of system's event would be a typical medical double-blind treatment, placebo and patient group[(5)]!

3. **<u>Tensor Qualities of Second Rank</u>** such as current density, $\underline{j}$, is equal to the vector product of electrical conductivity, $\underline{J}$, and electric field, $\underline{E}$, with each having three perpendicular components. Thus, in such a case, <u>3x3=9</u> numbers at a point are needed to completely specify, $\underline{j}$. Some other examples of second rank tensors are given in Table A.1[(6)] and each has 9 components, $\underline{T_{kl}}$, where <u>k≡(x,y,z)</u> and <u>l≡(x,y,z)</u> so one has terms like $\underline{T_{xx}}$, $\underline{T_{xy}}$, $\underline{T_{xz}}$, etc.

Table A.1		
Some Examples of Second-Rank Tensors Relating Two Vectors		
Tensor property	**Vector given or applied**	**Vector resulting or induced**
Electrical conductivity	Electric field	Electric current density
Thermal conductivity	(negative) temperature gradient	Heat flow density
Permittivity	Electric field	Dielectric displacement
Dielectric susceptibility	Electric field	Dielectric polarization
Permeability	Magnetic field	Magnetic induction
Magnetic susceptibility	Magnetic field	Intensity of magnetization

In the science of materials we also work with tensors of the third rank. For example, Piezoelectricity deals with stress-generated electric fields and this requires the use of a matrix of 3x3x3=27 numbers to completely specify this material property at a particular point in the material. We also have tensor qualities of fourth rank such as the elasticity properties of materials which, in general require the specification of 3x3x3x3=81 numbers at a point in a material to completely characterize that material property. Of course, various symmetries existing in the particular material under consideration (see group theory later) can somewhat reduce the total set of independent numbers needed to completely specify a tensorial material quality of second, third, fourth, etc, rank. At the simplest level of consideration, a tensor of rank n is a symbolic way to identify and write a material property that replaces 3^n numbers by a single symbol, T_n . These numbers become very important in operational computations of science/engineering importance to be discussed next.

4. **In Matrices and Determinants**[7] one puts all of the foregoing to work in quantitative calculations to obtain precise numbers with which we test our science theories about nature and the capabilities of our engineering to properly apply this scientific understanding to serve the needs of our world. To illustrate the meaning and use of these two words, consider a technical problem that requires the simultaneous solution of the n linear equations shown in Equation A.2a.

$$\left.\begin{array}{c} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n = y_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n = y_2 \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ a_{n1}x_1 + a_{n2}x_2 + \cdots + a_{nn}x_n = y_n \end{array}\right\} \qquad \text{(A.2a)}$$

Here, Equations A.2a relate a set of given variables x_1 ……x_n to a new set of variables y_1 …… y_n. These equations are said to **transform** the old variables into new ones and is called a linear transformation characterized by the set of coefficients, $\underline{a_{ik}}$. Since not only the values of the coefficients but also their relative positions in the equations are significant in this respect, a symbolic form for the characterization of the linear transformation is given by means of the rectangular array

$$\mathcal{A} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \qquad \text{(A.2b)}$$

which is called the **matrix** of the transformation. The matrix is a symbolic representation of the set of coefficients in their relative orientations. The algebra of matrices facilitates the manipulation of several sets of linear transformations. Although Equation A.2b has n rows and n columns, it could be an (mn)-matrix with m rows and n columns and in extreme cases, the matrix consists of a single row, $\lfloor\propto\rfloor$, or a single column, $\beta]$. If the rule for the multiplication of matrices is properly chosen, Equation A.2a can be written as a matrix equation of the type

$$\mathcal{A} \times \mathcal{B} = \mathcal{C} \quad \text{or} \quad \mathcal{A} \times x] = y] \qquad \text{(A.3a)}$$

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \times \begin{bmatrix} x_1 \\ x_1 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} y_1 \\ y_1 \\ \vdots \\ y_n \end{bmatrix} \qquad \text{(A.3b)}$$

Perhaps one of the most important rules in matrix multiplication is that, depending on the matrix sizes, matrix multiplication, at large sizes, violates the commutative law in the formation of algebraic product. Thus, if $\mathcal{A}$ and $\mathcal{B}$ are the two matrices, the product $\mathcal{A} \times \mathcal{B}$ may not be equal to $\mathcal{B} \times \mathcal{A}$ and has a different manipulative significance (which will be discussed below after a brief treatment of **determinants**).

The determinant of Equation A.2a is of the same arrangement as Equation A.2b but has a different set of brackets. This determinant, A, given by

$$\mathcal{A} = \begin{vmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{vmatrix} \qquad \text{(A.4)}$$

is a **function** of these coefficients and has a numerical value while the matrix, $\mathcal{A}$, is merely a picture. In outward appearance, the determinant differs from the matrix only in that the latter is enclosed in square brackets whereas, in the determinant, the elements are enclosed between vertical lines. Here, an upper-case script letter is used to denote a matrix while the upper-case italic letter denotes the corresponding determinant.

Quantitative evaluation of the simplest cases of two-row and three-row determinants are shown in Equations A.5a and A.5b, respectively, via the **diagonal product rule**.

$$\begin{array}{ccc} \text{principal diagonal} & & \text{negative product} \\ & \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} & \\ \text{conjugate diagonal} & & \text{positive product} \end{array} = a_{11}\,a_{22} - a_{21}\,a_{12} \qquad \text{(A.5a)}$$

$$\begin{array}{c} \text{negative products} \\ \begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} \boxed{\begin{matrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \end{matrix}}\ \text{repeated columns} \\ \text{positive products} \end{array} = \begin{array}{l} a_{11}a_{22}a_{33} + a_{12}a_{23}a_{31} + a_{13}\,a_{21}a_{32} \\ - a_{31}a_{22}a_{13} - a_{32}\,a_{23}a_{11} - a_{33}\,a_{21}a_{12} \end{array} \qquad \text{(A.5b)}$$

An extension of this diagonal-rule **does not** yield the value of fourth and higher determinants. The consequences of this in matrix theory are quite profound. Before moving to that topic, it is useful to show the mathematical solution (known as Cramer's Rule) for any particular x_k from Equation A.2a in determinant form, i.e.,

$$x_k = \frac{\begin{vmatrix} a_{11} & \cdot & a_{1,k-1} & y_1 & a_{1,k+1} & \cdot & a_{1n} \\ a_{21} & \cdot & a_{2,k-1} & y_2 & a_{2,k+1} & \cdot & a_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1} & \cdot & a_{n,k-1} & y_n & a_{n,k+1} & \cdot & a_{nn} \end{vmatrix}}{\begin{vmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{vmatrix}} \qquad \text{(A.6)}$$

Returning to matrix multiplication, $\mathcal{A}$ x $\mathcal{B}$, where each of two-row form, one finds that a four-row matrix is formed.

$$\mathcal{A} \times \mathcal{B} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \times \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \qquad \text{(A.7a)}$$

$$= \begin{bmatrix} a_{11} & a_{12} & -1 & 0 \\ a_{21} & a_{22} & 0 & -1 \\ 0 & 0 & b_{11} & b_{12} \\ 0 & 0 & b_{21} & b_{22} \end{bmatrix} \qquad \text{(A.7b)}$$

From Equation A.5a, Equation A.7a can be easily written down. Likewise, B x A can be easily written down. This shows quite readily that

$$\mathcal{A} \times \mathcal{B} - \mathcal{B} \times \mathcal{A} \neq 0. \qquad \text{(A.7c)}$$

All of us who take algebra in high school learn that the product of a and b is equal to the product of b and a. This is called **Abelian** algebra although most of us never learn that name. now we learn that a mathematical product in the form of a (4,4) or above matrix or determinant must be treated via **non-Abelian** algebra. The consequences of this are profound:

(i) If Equation A.2a is limited to n=3 then Abelian algebra can be used for quantitative analysis. However, if n=4 or more, then **non-Abelian** algebra must be utilized.

(ii) If relativistic mechanics is taken into account then 3-dimensional-vectors become 4-dimensional vectors so the product of two such vectors leads to a tensor or matrix of third rank and **non-Abelian** algebra is required for any analysis.

(iii) Heisenberg, of “The Uncertainty Principle” fame, utilized his matrix mechanics to show that the “Canonical Quantization Condition” was given by

$$pq - qp = h/2\pi i \qquad \text{(A.8)}$$

where p=momentum, q=coordinate, h=Planck’s constant and i is the imaginary number, i=√-1. Here, the requirement of **non-Abelian algebra** use leads to a stunning result!

B. **Symmetries & Group Theory**[8]: The most familiar symmetries in nature that are readily perceived by humans are spatial and geometric in appearance (like the hexagonal symmetry of the snowflake illustrated at the top of Figure 6)[9]

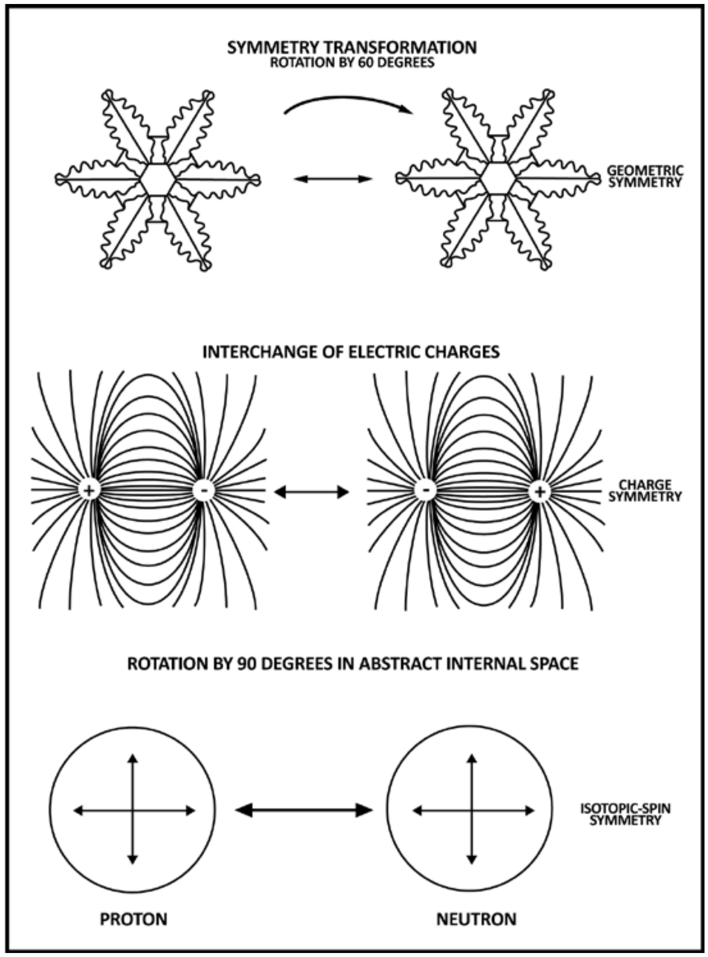


Figure 6. Symmetries of nature determine the properties of forces in Gauge theories. The symmetry of a snowflake can be characterized by noting that the pattern is unchanged when it is rotated 60 degrees; the snowflake is said to be invariant with respect to such rotations. In physics, non-geometric symmetries are introduced. Charge symmetry, for example, is the invariance of the forces acting among a set of charged particles when the polarities of all the charges are reversed. Isotopic-spin symmetry is based on the observation that little would be changed in the strong interactions of matter if the identities of all protons and neutrons were interchanged. Hence proton and neutron become merely the alternative states of a single particle, the nucleon, and transitions between the states can be made (or imagined) by adjusting the orientation of an indicator in an internal space. It is symmetries of this kind, where the transformation is an internal rotation or a phase shift, which are referred to as Gauge symmetries.

One notes that an invariance occurs in this geometrical pattern when it is rotated about its center either clockwise or counterclockwise by 60 degrees. In general, the state of an object can be defined by an **invariance** in pattern that is observed when some unique transformation operation is applied to it (e.g. a 60 degree rotation for the snowflake or a 90 degree rotation of a square).

As one reflects upon the five regular solids well known to ancient Greek Geometers (see Figure 12) and considers the operations of (1) reflection in a plane, (2) rotation about an axis and (3) inversion through a point, one detects new symmetries.

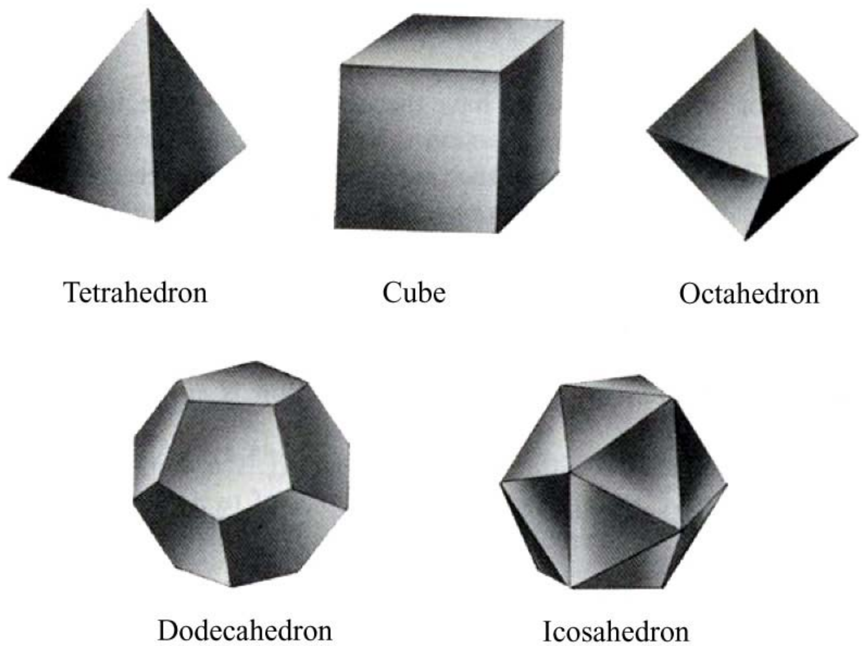


Figure 7. The five regular solids

Further, if one thinks of these five forms as actual crystals having this macroscopic habit (shape) with internal atoms, or molecules of some complexity, residing on a 3-dimensional microscopic array of regularly spaced lattice sites, one can also begin to recognize translational symmetry operations. Studying such operations in depth has led scientists to note that crystals are restricted to 32 such "crystallographic point groups". Within this recognized set of 32 crystallographic point groups, deeper study shows that it is possible to orient some point groups in more than one way with respect to a lattice and this has led to the discrimination of 230 "space groups" exhibiting a microscopic local symmetry classification **within** a more global macroscopic symmetry classification.

This primarily descriptive classification of space groups has been put on a firmer foundation via "group theory" with its various mathematical complexities, most of which are beyond the intent of this White Paper, buy involve expressing each symmetry operation as a matrix (see Part A). This involves one of the symmetries of the vibrational spectra of atoms, bonding orbitals of atoms and energy bands in both microscopic and macroscopic arrays of atoms/molecules. Therefore, group theory must deal with the transformational operations involved in the physics of all these additional levels of symmetry in order to make **everything** internally self-consistent.

C. Internal symmetry and Gauge Theory[3,10]

The concept of a "Gauge" was introduced in 1918 by Herman Weyl to mean a standard of length whereby the gravitational force could be formulated in terms of the curvature of space and the various geometries involved. In general, Gauge Theories were constructed to relate the properties of the four known fundamental forces of nature to the various symmetries of nature (see Figure 6). The most familiar symmetries are spatial or geometric in appearance, like the hexagonal symmetry of a snowflake. An invariance in the snowflake pattern occurs when it is rotated by 60 degrees. In general, the state of symmetry can be defined as an **invariance** in pattern that is observed when **some** transformation is applied to it (e.g., a 60° rotation for the snowflake or a 90° rotation for a square).

One example of a non-geometric symmetry is the charge symmetry of electromagnetism. For the case of a collection of electric dipoles, if the individual charges are suddenly reversed in sign, the energy of the ensemble is unchanged so the forces remain unchanged. The same behavior occurs for magnetic dipoles and electromagnetic fields in general (this is because the energy is proportional to E^2 and to H^2 so it does not change by a 180° rotation of the dipoles). Another symmetry of the non-geometric kind relates to **isotopic-spin** of particles, a property of neutrons, protons and hadrons (the only particles responsive to the strong nuclear force). The symmetry transformation associated with isotopic-spin rotates the **internal indicators** of all protons and neutrons everywhere in the universe by the same amount and at the same time. If the rotation is by exactly 90 degrees, every proton becomes a neutron and every neutron becomes a proton so that no effects of this transformation can be detected and this symmetry is invariant with respect to isotopic-spin transformation.

All of these described symmetries are **global symmetries** (happening everywhere at once). In addition to global symmetries, which are almost always present in a physical theory, it is possible to have a **local** symmetry[3]. For a local symmetry to be observed, some law of physics must retain its validity (remain invariant) even when a different transformation takes place at each separate point in space-time. Gauge Theories can be constructed with either a global symmetry or a local symmetry (or both). However, in order to make a theory invariant with respect to a local transformation something new must be added. This new something is a new force[3].

The first Gauge Theory with local symmetry was the theory of electric and magnetic fields, introduced in 1868 by James Clerk Maxwell. The character of the symmetry that makes Maxwell's theory a Gauge Theory is that the electric field is invariant with respect to the addition or subtraction of an arbitrary overall electric potential. However, this symmetry is a global one because the result of experiment remains constant only if the new potential is changed everywhere at once (there is no absolute potential and no zero reference point). A complete theory of electromagnetism requires that the global symmetry of the theory be converted into a local symmetry. Just as the electric field depends ultimately on the distribution of charges, but can conveniently be derived from an electrical potential, so the magnetic field generated by the motion of these charges can be conveniently described as resulting from a magnetic potential. It is in this system of potential fields that local transformations can be carried out leaving all the original electric and magnetic fields unaltered. This system of dual, interconnected fields has an exact local symmetry even though the electric field alone does not[3].

Maxwell's theory of electromagnetism is a classical one, but a related symmetry can be demonstrated in the quantum theory of EM interaction (called quantum field theory). In the quantum theory of electrons, a change in the electric potential entails a change in the **phase** of the electron wave and the phase measures the displacement of the wave from some arbitrary reference point (the difference is sufficient to yield an electron diffraction effect). Only differences in the phase of the electron field at two points or at two moments can be measured, but not the absolute phase. Thus, the phase of an electron wave is said to be inaccessible to measurement (requires a knowledge of both the real **and** the imaginary parts of the amplitude) so that the phase cannot have an influence on the outcome of any possible experiment. This means that the electron field exhibits a symmetry with respect to arbitrary changes of phase. Any phase angle can be added to or subtracted from the electron field and the results of all experiments will remain invariant. This is the essential ingredient found in the U(1) Gauge condition.

Although the absolute value of the phase is irrelevant to the outcome of experiment, in constructing a theory of electrons, it is still necessary to specify the phase. The choice of a particular value is called a Gauge convention. The symmetry of such an electron matter field is a global symmetry and the phase of the field must be shifted in the same way everywhere at once. It can be easily demonstrated that a theory of electron fields, along with no other forms of matter or radiation, is **not** invariant with respect to a corresponding local Gauge transformation. If one wanted to make the theory consistent with a local Gauge symmetry, one would need to add another field that would exactly compensate for the changes in electron phase. Mathematically, it turns out that the required field is one having infinite range corresponding to a field quantum with a spin of one unit. The need for infinite range implies that the field quantum be massless. These are just the properties of the EM field, whose quantum is the photon. When an electron absorbs or emits a photon, the phase of the electron field is shifted[3].

The freedom to move the origin of a coordinate system constitutes a symmetry of nature. Actually there are three related symmetries: All the laws of nature remain invariant when the coordinate system is transformed by translation, by rotation or by mirror reflection. However, these symmetries are only global ones and each symmetry transformation can be defined as a formula for finding the new coordinates of a point from the old coordinates. Those formulae must be applied simultaneously and in the same way to all the points. The general theory of relativity stems from the fundamental observation that the structure of space-time is not necessarily consistent with a coordinate system made up entirely of straight lines meeting at right angles. As in electrodynamics, for relativity theory, local symmetry can only be generated from the global symmetry condition by adding a new field to the theory. In general relativity, the field is that of gravitation[3].

The symmetry at issue for the SU(2) Gauge is the isotopic-spin symmetry with the rule that the strong interactions of matter remain invariant (or nearly so) when the identities of protons and neutrons are interchanged. In the global symmetry, any rotation of the internal arrows that indicate the isotopic-spin state must be made simultaneously everywhere (see Figure 8). A local symmetry allows the orientation of the arrows to vary independently from place to place and from moment to moment as an arbitrary function of position and time. As in other instances where a global symmetry is converted into a local one, the invariance can be maintained only if something else is added to the theory. Constructed on the model of electromagnetism, Yang and Mills found that, when isotopic-spin rotations are made arbitrary from place to place, the laws of physics remain invariant only if six new fields are introduced. They were all vector fields, they all had infinite range (and were therefore massless) and they were non-Abelian (the order of the rotations was important whereas for EM, and Abelian Theory, the rotation order is not important). Although the Yang-Mills Theory was of monumental importance, it needed considerable fine-tuning to describe the real world.

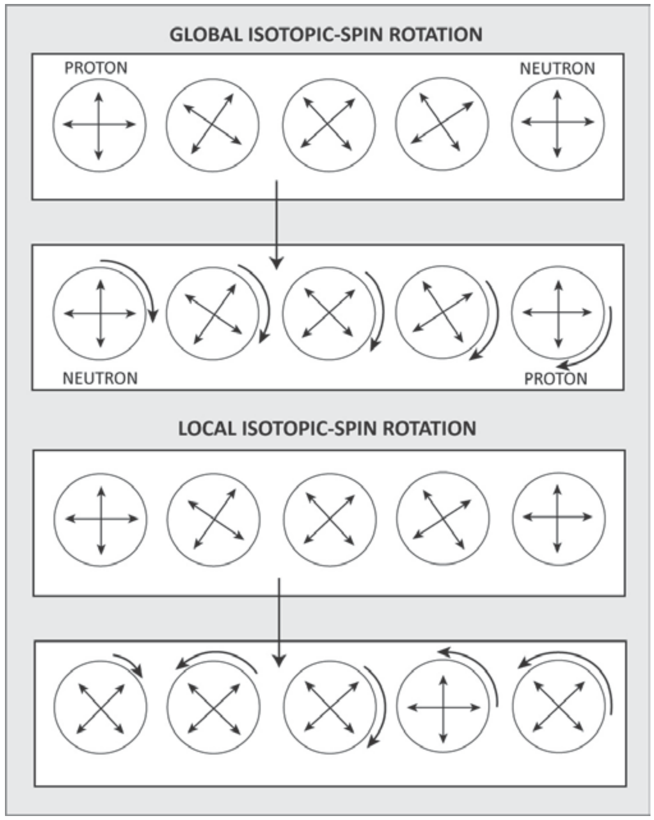


Figure 8. Isotopic-spin symmetry serves as the basis of another Gauge Theory. If isotopic-spin symmetry is valid, the choices of which position of the internal arrow indicates a proton and which a neutron is entirely a matter of convention. Global symmetry (upper diagram) requires the same convention to be adopted everywhere, and any rotation of the arrow must be made in the same way at every point. In the Yang-Mills Theory, isotopic spin is made a local symmetry (lower diagram), so that the orientation of the arrow is allowed to vary from place to place. In order to preserve the invariance of all observable quantities with respect to such local isotopic-spin transformations, it is necessary to introduce at least six fields, corresponding to three massless vector particles one of which can be identified as the photon.

One strategy adopted in an attempt to fix its defects was to artificially endow the charged field quanta with a mass greater than zero. Imposing a mass on the quanta of the charged fields confines them to a finite range and, if the mass is large enough, the range can be made as small as is wished. Ultimately, a way was found to endow some of the Yang-Mills fields with mass while retaining exact Gauge symmetry. This technique is now called the Higgs Mechanism(3).

The fundamental idea of the Higgs Mechanism was to include in the theory **an extra field,** one having the peculiar property that it does not vanish in vacuum. The Higgs field is unusual in that reducing it to zero costs energy. The energy of the field is smallest when the field has some uniform value **greater** than zero. The Higgs field is a scalar quantity, having only a magnitude (like temperature) and so the quantum of this field must have a spin of zero. The Higgs Mechanism is an example of a well-established process called spontaneous symmetry breaking. Over the last two decades, this approach has further evolved into quantum chromodynamics requiring an invariance with respect to local transformations of quark color leading to the quanta of the color being called gluons (because they glue the quarks together). As ‘t Hooft[3] states, many questions still remain unanswered “why do the quarks and the other elementary particles have the masses they do? What determines the mass of the Higgs particle? What determines the fundamental unit of electric charge or the strength of the color force?” The answers to these questions requires an even more comprehensive theory so one continues to search for other global symmetries and then explores the consequences of converting them to local symmetries.

Gauge Theory allows us to understand how the fundamental forces of nature can be unified within a single coherent theory. Today, it dominates nearly all phases of elementary particle physics. In addition, its potential areas of application extend far beyond elementary physics[3]. Gauge Theory represents a new synthesis of quantum mechanics and symmetry.

One essential requisite for the study of Gauge Theory is at least a nodding acquaintance with some of the terminology of group theory (see Section B). The heart of any Gauge Theory **is the Gauge symmetry group** and the crucial role that it plays in determining the dynamic of the theory. The crucial difference in group theory is that the symmetry group is not associated with any physical coordinate transformation in space-time. Gauge Theory is based on an **internal** symmetry. In particular we will see that the proper understanding of Gauge invariance leads naturally to a geometrical description of Gauge Theory.

The concept of Gauge invariance was first proposed by Hermann Weyl in 1919 as an inspiration generated in response to Einstein’s great success with his theory of general relativity. Although the specifics of Weyl’s physical interpretation of Gauge invariance was soon shown to be incorrect by Einstein, it had sufficient merit that the general concept was found to be useful elsewhere. The concept of “Gauge” implies a measuring device which one might use as in Figure 3, where the gravitational force change from moving from the position x to the position x+dx in space could be considered to be linearly related to the change in scale amplification of the measuring device (the Gauge).

From Einstein, the fundamental concept underlying both special and general relativity is that **there are no absolute frames of reference in the universe**. The physical motion of any system through space must be described relative to some arbitrary coordinate frame specified by the observer[3], and the laws of physics must be **independent** of the choice of frame. In special relativity, one usually defines convenient reference frames (RFs) which are called internal (i.e. moving with uniform velocity). In general relativity, the description of relative motion between an object moving at constant velocity, υ, with respect to an observer, is much more complicated because, now, one is dealing with the motion of a system **in the presence** of a gravitational field. One finds that an essential difference between special and general relativity is that, in the latter case, an RF can only be defined “locally” or at a single point in a gravitational field.

Einstein solved the problem of multiple local RF’s by defining a new mathematical relationship know as a “connection” and used curvilinear coordinates to link x and x^1=x+dx in Figure 9 with the value of the connection at each point in space-time being dependent on the properties of the gravitational field. In this way, Einstein arrived at the revolutionary idea of replacing gravity with the curvature of space-time in general relativity.

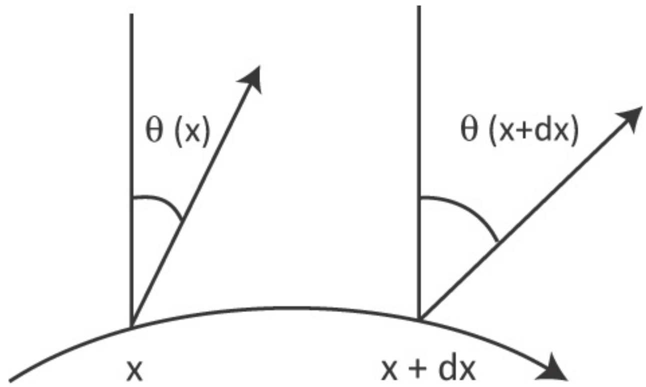


Figure 9. Rotation of the internal space direction of a moving test particle. The internal angles change from θ(x) to θ(x + dx) as the test charge moves from x to x + dx.

With the development of quantum mechanics, (QM), Weyl and others realized that his original Gauge concept could be given a new meaning. The essential clue was the realization that **the phase of a wave function** could be treated as a new local variable. **Instead of a change of scale, a Gauge transformation was reinterpreted as a change in phase** of the wave function ($\psi = \psi^{i\theta}$ where θ = eλ is the phase angle). A different choice of phase, θ, at each point in space can then be accommodated easily by interpreting the electromagnetic vector potential, $\underline{A}$, as a connection that relates phases at different points. Thus, within the new environment of QM, Gauge invariance was rediscovered as invariance under a change in phase. The so-called **arbitrariness** formerly ascribed to the electromagnetic vector potential, $\underline{A}$, was now understood as the freedom to choose any value for the phase of a wave function without affecting the equations of motion.

The groups that are most useful in Gauge Theory are known as continuous groups. These groups possess properties which are very different from the various crystal symmetry groups or the set of permutations of n objects. Continuous groups contain an infinite number of elements. A simple example of a continuous group is the set of all complex phase factors of a wave function in QM (U(θ) = exponential of iθ = $e^{i\theta}$).

Yang and Mills, in 1954, were the first to show that local Gauge symmetry was a powerful fundamental principle that could provide new insight into the newly discovered **internal** quantum numbers like isotopic spin (see Figure 8). They revived the old ideas that elementary particles might have new degrees of freedom in some kind of “internal” space. As an example, the phase factor mentioned earlier, $e^{i\theta}$, form a group which is called U(1), for a **one-dimensional unitary group**. Here, each element of U(1) is characterized by a unique angle, θ, which is a continuous parameter that can take an infinite number of values between 0 and 2π as indicated in Figure 2. To an imaginary observer **inside** this internal space, the interaction between a particle and an external Gauge field looks like a simple rotation of the local coordinates. The amount of the rotation is determined by the strength of the external potential.

The geometrical structure of Gauge Theory can be illustrated via a very convenient intuitive picture (see Figure 1). Here, space-time is represented by the horizontal plane and the internal symmetry space is drawn vertically at each point. The vertical line in the figure depicts the case of a one-dimensional internal space like that of the U(1) group. This internal space is called a fiber by mathematicians. In this picture, the spatial location of a particle is given by a coordinate point in the horizontal plane while the orientation in the internal space is specified by angular coordinates in the "fiber" space. As the particle moves through space-time, it traces to a path in the internal space above the space-time trajectory (see "phase" in Figure 4). When there is no external Gauge potential, the internal space path is completely arbitrary (the angles θ and ϕ hop around in Figure 4). When the particle interacts with external Gauge fields, the paths of θ and ϕ in the internal space (Figure 4) is a continuous curve determined by the Gauge potentials.

The idea of using a Gauge potential to "marry" together space-time with an internal symmetry space is a new concept in physics. In mathematical jargon, the new space formed by the union of four-dimensional space-time with an internal space is called a "fiber bundle" space. The reason for this name is that the internal space (or fibers) at each space-time point can be viewed as the same space because they can be transformed into each other by **a Gauge transformation**[3,10]. The internal phase angle for the U(1) group of electromagnetism is constrained to move within the circle of Figure 2 at every space-time point. However, for the SU(2) group, it is necessary to attach a sphere at each space-time point because we now have **two** different and independent internal phase angles, θ and ϕ, to deal with. This is illustrated in Figure 4.

Other examples of continuous groups are very important to physics. One is the O(3) group whose parameters are the three rotation angles in three-dimensional space (the Euler angles) that are very important for today's satellite placement and dynamics. The most interesting continuous groups, from the point of view of Gauge Theory are called Lie groups after Sophus Lie (1842-1899), their inventor[3]. The distinguishing characteristic of a Lie group is that the parameters of a product must be analytic functions of the parameters of each factor in the product ($U(\gamma) = U(\propto)U(\beta)$ where $\gamma = f(\propto, \beta)$ and $f(\propto, \beta)$ is an analytic function of $\propto$ **and** β).

Unitary transformations are well known in QM because they leave the modulus squared of a complex wave function invariant. The elements of the unitary group U(n) are represented by n x n matrices which have a determinant value of ±1. The elements of U(n) with determinant equal to +1 defines the special unitary or unmodular group SU(n) whose elements have n^2-1 independent parameters. The interesting SU(n) group encountered in Gauge Theory are the SU(2) group of isotopic spin and the SU(3) group associated with "colored" quarks and gluons in quantum chromodynamics (QCD), a **non-Abelian** Gauge Theory created by S. Weinberg (1967) and A. Salam (1968).

Correlations Between Gauge Theory Considerations and Our Intention-Hose Device (IHD) Experiments

As stated elsewhere[2,12], the unstated assumption of our orthodox science for the last 400 years has been that "no human qualities of consciousness, intention, emotion, mind, spirit, etc, can significantly influence a well-designed target experiment in physical reality". In 1997, with a few colleagues and a philanthropist's funding, I mounted a three-year, **serious** test of this unstated assumption in today's world. The dramatic results of this test were published in Reference 9.

Four uniquely designed target experiments, and many other related experiments, on the effects of applied human consciousness in the form of four specific intentions, on significantly altering the properties of physical materials (both inorganic and organic (in vitro and in vivo)) were carried out. All four experiments were robustly successful[9,2]. One of these has been successfully replicated by others[13-16].

During the 2000 to 2010 decade it was noted that, as a consequence of our experimental results, the EM Gauge symmetry state of the experimental spaces appeared to be **raised** from their normal U(1) state to the SU(2) state. At the same time, the excess thermodynamic free energy of the aqueous H^+-ion in a pH-sensor probe[17] increased substantially during the transition of the experimental space from the U(1) to this seeming SU(2) state. It was further found that attaining an SU(2) Gauge level in the experimental space was a necessary prerequisite for attaining such robust experimental results with the four IHD target experiments.

Three key experimental signatures heralded the onset of what we called "space conditioning". One of these, in particular, was very important in our postulation that a partial SU(2) EM gauge symmetry state had been established in the experimental space. These three signatures were[18]:

(1) A D.C. magnetic field-polarity effect wherein the **south-labeled** magnetic pole pointing upwards into a pH-measuring water vessel produced a large increase in the pH-measurement (more alkaline) while (ii) the reverse polarity **north-labeled** pole pointing upward into the water, led to a substantial **decrease** in the pH-measurement (more acidic). It is not possible for this to occur in a normal U(1) gauge state space because only magnetic dipoles are present in such a Gauge state, both the magnetic force and magnetic energy are proportional to H^2 (so "sign" effect is not relevant) and no geometrical orientation can occur.

(2) The development of very low frequency oscillations, in the 10^{-1} to 10^{-4} hertz range, for air temperature, water temperature, pH and electrical conductivity of the water and

(3) The development of macroscopic coherence effects in both the air and the water over distances of ~10 feet wherein, for all four time-dependent property measurements, their Fourier spectra **completely** nested with each other.

Anomaly #1 above, the D.C. magnetic field polarity effect, became a "signature" strongly suggesting to us that an IHD-conditioned space allowed us to experimentally access individual magnetic charges because the space had lifted to an SU(2) Gauge level (in our case electric charge plus magnetic charge with deltron coupling). Following this hypothesis, we were able to experimentally show that, in the living human body, the acupuncture meridian system is always at a partially coupled state of physical reality (the SU(2) state) within the matrix of a U(1) state body[19,20].

In this regard, my working hypothesis for an IHD-treated experimental space is that (a) deltrons flow out of the imprinted IHD into the room, (b) these react with information wave substance in the vacuum level of that experimental space converting them to "conscious" magnetic information wave substances which (c) then react with electron charge-based substances of the U(1)-state materials of the experimental space which, in turn, (d) slowly build in concentration and, at some level of supersaturation, nucleate and grow small but macroscopic-sized SU(2) domains within the matrix of these U(1) state materials (see Figure 10); thus (e) this is thought to lead to a composite of SU(2) domains in a U(1) matrix of volume fraction, $v_{SU(2)}/[1-v_{SU(2)}]$ which, in turn, is thought to be proportional to the coupling coefficient, $\propto_{eff}$, between our coarse physical substance (D-space) and an aspect of our finer, vacuum level substance (R-space).

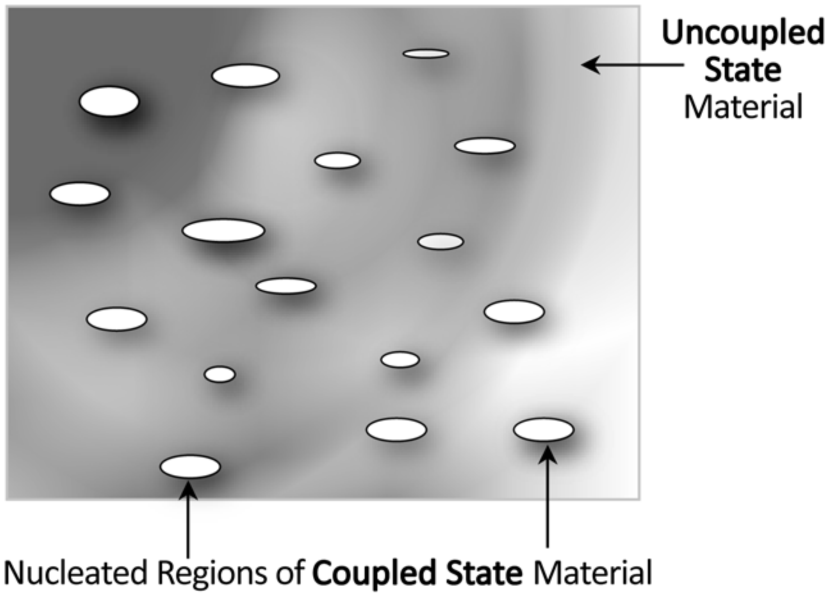


Figure 10. Nucleation and growth of the macroscopic coupled state of physical reality.

Perhaps the most important point to recognize here is that the local **internal** symmetry state of both an experimental space and a human can be significantly altered by disciplined and focused intention of either the IHD-type or the strongly-developed human biofield-type. Just as today's orthodox physics has external distance-time-dependent fields controlling the **internal symmetry** phase angle maps of various designated D-space material Gauge states, so also does psychoenergetic science have external frequency domain biofields and R-space intention fields that control the **internal symmetry** phase angle patterns of various designated human Gauge states via expanded group theory expressions.

Some Relevance of all this to Psychoenergetic Science

Psychoenergetic science is the expansion of today's orthodox science to include consciousness and intention as meaningful thermodynamic variables in the investigation of nature's many forces and fluxes. The long-term goal is to bring balance and harmony to our world which requires the union of Logos (outward directed attention) and Mythos (inward directed attention). These newly appreciated thermodynamic variables allow the manipulation of various forms of **information** in nature which, in turn, creates a quantitative inverse effect on thermodynamic **entropy** and thus manifests in nature as true thermodynamic forces, on par with our familiar energy-driven forces.

In this expansion of today's orthodox science efforts to more fully understand nature, and particular, **various life forms** in nature, the reference frame that we use to quantify our scientific efforts needs to be expanded from our present four-dimensional distance-time-only RF to a provisional duplex RF consisting of two, four dimensional reciprocal subspaces, one of which is distance-time. Using such a duplex RF, a zeroth order approximation to the proper mathematical description of nature's behavior, as seen by the experimentally measured quality or property, Q_M, is found to be

$$Q_M = Q_e + \propto_{eff} Q_m. \qquad (9)$$

Here, Q_e, represents that for our electric atom/molecule world (D-space) and, mathematically, will be a scalar or vector but often a tensor while Q_m represents that for the magnetic information wave world (R-space) of the physical vacuum which, mathematically will be a vector or tensor. Here, $\propto_{eff}$ is the deltron coupling coefficient ($0 \gtrsim \propto_{eff} \lesssim 1$) which, mathematically will be a vector or tensor. Thus, working with Q_M in a quantitative way will involve group theory factors and Gauge symmetry factors plus Abelian/non-Abelian algebra considerations. In Equation 9, when $\propto_{eff}$ is greater than ~0.05, one can expect that about 5 percent of the spatial volume of the experimental space is at the SU(2) Gauge level while the other 95% is still at the U(1) level.

This SU(2) volume fraction is a thermodynamically metastable phase which is always "leaking" deltrons at some finite rate out of the experimental space; thus, if this deltron loss rate is not replenished from **some source**, $v_{SU(2)}$ will decay at some rate. Eventually "symmetry breaking" will occur and this upper curve in Figure 4 and the entire experimental space will drop back to the lower curve in Figure 4, the U(1) Gauge state which is today's world's thermodynamic equilibrium state.

The SU(2) Gauge state domains of Figure 10 theoretically require 3 (2^2-1) independent parameters to be present for group stability. In our case they appear to be (1) the electron wave function phase angle, θ, (2) the magnetic monopole wave function phase angle, ϕ, and (3) activated deltrons which introduce a "consciousness" property to this macroscopic coupled state system. In living vertebrates, one presumes that their acupuncture meridian system contains some minimum volume fraction of small SU(2) domains to maintain what we call "life". These are probably pumped with active deltrons from higher dimensional chakra systems. In Qigong Masters or saints versus normal individuals, $v_{SU(2)}$ is probably greatly increased. As humans do "inner" work on themselves, they create significantly enhanced infrastructure within the Mythos aspects of themselves and achieve many presently unidentified human Gauge symmetry states. This appears to be our path forward in the long-term development of the human species.

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