

Global-Local Gauge Symmetries and the "Tetrahedron Model" Part II: Postscript

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(Revised April, 2011)

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Introduction: Duality in Nature

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From ancient times we have intuited and named a dual level of reality - it is a defining characteristic of abstract thinking, symbolic language, and the human condition. This recognition of abstract reality has its most explicit social expression in our religious (and political) systems of thought, the realm of the gods (and the State) vs the realm of humanity and the "citizen", religious and secular law. Plato recognized it as the realm of ideal forms vs the realm of their material "shadows". Duality takes additional forms in philosophical, ethical, moral, and aesthetic conceptual systems. In our own physiology, in addition to the biological duality of gender, we seem divided between the intangible realm of thought and imagination and the realm of physical action and the body (mind-brain). In science we recognize dualities between the realm of physical or natural law vs the realm of phenomena, the theoretical vs the experimental, mathematics vs material reality, symbol vs substance, and virtual or potential vs actual or realized forms of energy, among many others.

A significant duality in mathematical physics is expressed as "global vs local gauge symmetry" - a methodology of conceiving the laws and phenomena of physics that is especially conducive to mathematical formulation ("group theory"), and is currently the favored theoretical approach in the ongoing search for the "Holy Grail" of physics, Einstein's dream of a unified field theory.

The world is a mysterious place, and not just in terms of the enduring question of humanity's role in the Cosmos. We find in all natural phenomena a variety of "hidden", relative, or emergent forces. This is nowhere more evident than in the paradoxes of relatively and quantum mechanics, enigmas at the very foundations of physics (spacetime warps, "non-locality", etc.).

At the level of the four forces, we have the mysteries of gravitation, time, and magnetism in the long-range, "spacetime" forces. These are local effects set against and derived from the global invariants of electromagnetism: "velocity" c , the spatial metric, and electric charge. In the particle or short-range

forces, we find the hidden "identity" or "number" charges of the massive leptons, the Heisenberg-Dirac virtual vacuum "zoo" of particle-antiparticle pairs, and the strange realm of the weak force, with its massive IVBs, ghostly neutrinos, spontaneous symmetry-breaking, the creation and destruction of matter, etc. Finally, in the strong force we have the permanently confined and forever hidden quarks with their partial quantum unit charges, and the gluon field of "sticky light", exchanging color charges between quarks at velocity c .

The atomic realm is a hive of activity completely beneath our notice - the whirling electrons in their orbits, the exchange of virtual mesons between "nucleons" in the compound atomic nucleus, and the frenzied exchange of gluons between quarks within baryons. The "vacuum" bubbles and froths with the creation and annihilation of Heisenberg's virtual particles; neutrino, gravitational, and electromagnetic waves of every description traverse the Cosmos unrecognized - either for lack of biological sensory apparatus or physical interaction. Yesterday, historical spacetime, and the "realm of the ancestors" is largely hidden from our view, even though its continuing reality in some alternative, causal form cannot be doubted - as it sustains our own reality today in the universal present moment, or "now". (See: "[A Spacetime Map of the Universe](#)".)

These are some of the documented, rational, "scientific" physical phenomena, and I have only mentioned the tip of the iceberg. Is it any wonder we have intuited a hidden, parallel, "occult" universe of paranormal effects and miracles, of gods, angels, and demons? Of "Paradise" or "Heaven", a conservation domain of spirit and the eternal realm of invariant Divine Law - where all humanity finds itself in a globally symmetric state of universal spiritual equality?

Global vs Local Gauge Symmetries

While the title of this paper may sound formidably obtuse, it is typical physics-speak for a simple but powerful idea: the value or magnitude of certain universal constants, such as the electromagnetic constant " c " and charges of all kinds, must be maintained and protected, for excellent and obvious reasons of conservation, including energy, symmetry, and causality. This is not a particularly difficult task in the perfect realm of light and space, where in the absence of matter, time, and gravity, all velocities are " c ", all charges are virtual, and all energy forms are non-local and massless. In our actual, compounded world of free and bound types of electromagnetic energy, however, we find (in addition to light) massive particles bearing various real charges, having specific locations in spacetime, and moving with various relative motions. Time and gravity are also present wherever matter is present.

In this highly complex "real" rather than "ideal" world, maintaining the constant value of c and various charges, etc., is a difficult but nonetheless necessary task, requiring some extra help from ancillary forces which have come to be known as "local gauge symmetry forces". Because it is the real world and not the ideal world we ordinarily inhabit, these local forces are among the most familiar of our daily experience: gravity, time, and magnetism, among others.

The concept of symmetry is central to the modern effort to achieve Einstein's dream of a unified field theory of physics. I have used the concept extensively in my work (See: "[Symmetry Principles of a Unified Field Theory](#)"), but from a slightly different perspective than that of "establishment" physics. (See: *The Moment of Creation* by James S. Trefil, 1983, Macmillan, pages 87-125 for an expert but non-mathematical explanation of the use of symmetry concepts in the "standard model" of unification physics.)

Although the global-local gauge symmetry concept is often couched in purely numeric terms of the universal vs the individual, for reasons of physical relevance I have broadened this usage to include the category of absolute motion vs relative motion. As I employ the terms, absolute stands to relative

as global stands to local or as the universal stands to the individual. The relative is unpredictable and peculiar to the individual. The task of local gauge symmetries is to maintain within the temporal, unpredictable, individual, and relative material domain some essential, conserved aspect of the global invariant - for example, the invariance of the magnitude of electric charge despite the freedom of relative motion of individual massive charge carriers (electrons, protons, mesons, etc.).

Mathematical physics distinguishes between the concepts of "global" vs "local" gauge symmetry: "local" gauge symmetries are derived from and represent individual variations upon universal or "global" gauge symmetries. The word "gauge" refers to a regulating property that establishes a magnitude or scale, as for example the value of the electromagnetic constant (c), a global symmetry gauge for electromagnetic energy and the spatial metric. The magnitude of the electric charge (e), Planck's energy constant h , the value of the universal gravitational constant (G), and the mass of the Higgs boson, also represent global gauge constants. On the other hand, a magnetic field, the time dimension, the massive IVBs (Intermediate Vector Bosons) of the weak force, and the gluon field of the strong force, are all local gauge "currents" of matter (field vectors of the forces) which establish and maintain local gauge symmetries. Cold, crystalline, and neutral atomic matter is the prototypical example of an energy form established and maintained by "local gauge symmetry currents" from a globally symmetric energy form - light.

Light (free electromagnetic energy) is a globally symmetric energy state from which locally asymmetric atomic matter (bound electromagnetic energy) is devolved. The charge neutrality and inertial stasis of cold, quiescent atomic matter is the evidence of a locally symmetric energy state, involving charge conservation and neutralization, alternative charge carriers, and inertial forces, which is achieved or derived from, and replaces, the globally symmetric energy state of light. In many respects, the local symmetry state is just as invariant and conserved as the global one, and in fact the two regimes are in constant interaction and equilibration (through virtual particles and other quantum effects of the spacetime "vacuum", long-range electromagnetic and gravitational fields, etc.). However, the fact that forces are at work in our local environment (gravity is the obvious example, in our experience of "weight" and in the radiance of our Sun; radioactivity is another example), tells us that the two systems of light and matter are not yet in a state of complete equilibrium.

The reason why we have a dual system of global vs local gauge symmetries in physical law and phenomena is because our Universe consists of massive, local energy forms in relative motion (matter), which are derived from light - a massless, non-local (global) energy form in absolute (invariant) motion. Functionally, the local symmetries are embodied and enforced through the field vectors of the forces. The field vectors translate timeless global symmetries (such as the virtual charges of matter-antimatter particle pairs) into alternative, material, local, temporal forms (such as the real charges of atomic matter). These local charges conserve the invariant values of the original global symmetries through time, until they can be returned (via the action of their associated forces) to their original symmetric form, light (typically via charge-anticharge annihilations).

Through an (as yet) unknown mechanism of "spontaneous symmetry-breaking" during the "Big Bang", high-energy light, interacting with the metric structure of spacetime, produces matter (from particle-antiparticle pairs via asymmetric weak force decays, probably of electrically neutral [leptoquark-antileptoquark pairs](#)). Matter carries active charges (and spin) from one pair member, which represent symmetry debts (since charges exist to motivate and facilitate annihilation reactions with the absent pair member and so restore light's waveform or "non-local" symmetry state). *The charges of matter are the symmetry debts of light* (Noether's Theorem.) These charges produce forces which act to return matter (sooner or later) to its original symmetric form, light. Our Sun is the archetypical example of this universal phenomenon and natural agenda in action (symmetry conservation as required by Noether's Theorem, and achieved by the spontaneous activity of the

forces of physics).

While the ultimate role of the field vectors of the four forces is to return matter to light, their proximate role is to translate globally invariant symmetries into locally invariant charges. The reason why they bother to do this is because in the absence of antimatter (following "Big Bang" symmetry-breaking), local symmetry-keeping and charge conservation is a necessary maintenance function in the pathway leading to the eventual and complete restoration of light's original symmetric non-local energy state - a restoration required by symmetry conservation and Noether's Theorem.

The charges of matter are derived from invariant global gauge symmetries, and their field vectors (including the graviton, or time) represent local gauge "currents" establishing and maintaining similarly invariant local charge magnitudes. The field vectors, in addition to transmitting the forceful effect of the charge, must also protect, conserve, or otherwise maintain the invariant magnitude of the charge. Symmetry conservation = charge conservation, which is why charge invariance is so important. Charge and symmetry conservation would have little meaning if charge invariance was not rigorously enforced. This is why all field vectors, in dealing with the relative energy state of matter, must have a flexible component or capability, like the photon's magnetic field, whose strength varies with the relative motion of electric charge. The flexibility of the local component is what protects the inflexible (invariant) global component in the unpredictable and turbulent domain of matter and relative motion.

Mathematical physics uses symmetry principles to obtain quantitative equations describing the operation of the forces, and for predictions and explanations of experimental results. I use the concepts of symmetry in a non-mathematical, qualitative way to understand why the forces act as they do, and why they must exist in nature. The concepts of symmetry, when properly applied, provide a broad avenue to the understanding of nature - equivalent to the fundamental and powerful ideas of entropy, causality, and energy conservation (See: "[The Tetrahedron Model](#)"). Both establishment physics and I have been successful in our own ways. This paper (and others in the global-local gauge symmetry series) is an attempt to join the perspectives of the "Tetrahedron Model" and the "Standard Model", not mathematically (because that desideratum is quite beyond my ability), but conceptually, in English. (See also: [The "Tetrahedron Model" vs the "Standard Model" of Physics: A Comparison.](#))

Global-Local Parameters in the Electromagnetic Force - General Considerations

The conversion of light to matter, free electromagnetic energy to bound electromagnetic energy, during the "Big Bang", represents the conversion of a globally symmetric form of energy (matter-antimatter symmetry, space, and massless "non-local" light with intrinsic spatial motion "c") to a locally asymmetric form of energy (matter, time, and massive local particles with no (net) intrinsic spatial motion). In purely energetic terms, this conversion is symbolized by DeBroglie's equation: $h\nu = mcc$. For simple reasons of conservation, a local form of energy (massive particles of matter) requires a local form of entropy (time), a local form of symmetry (charge), a local form of metric (gravitational spacetime), a local connectivity domain (history, causality). Charge invariance with whole quantum charge units, the invariance of velocity c, the "Interval" and causality, and the invariance of elementary particles: all are conservation mandates which follow upon the transformation of free to bound electromagnetic energy during the "Big Bang", and which necessitate the existence of various sorts of local gauge symmetry currents.

The original and primordial global-local conversion of our primary electromagnetic energy form (light), is accompanied by the gravitational conversion of globally symmetric space with its spatial entropy drive (the intrinsic motion of light), to locally asymmetric history with its historical entropy drive (the intrinsic motion of time). Finally, light's symmetric energy state, which is realized (in its

particle form) as globally symmetric matter-antimatter particle pairs, is converted (quantum-mechanically through an asymmetry in the weak force), to locally asymmetric matter-only charges.

Charge conservation = symmetry conservation (Noether's Theorem), in which charges are carried by massive particles and conserved through time. The conserved charge-symmetry debt of matter is fully repaid when charges are eventually annihilated by antimatter charges. The entropy-interest on matter's symmetry debt is paid by gravitation, which creates the time dimension of matter by the annihilation of space and the extraction of a metrically equivalent temporal residue. The spatial expansion of the Universe is consequently slowed as it supplies energy for the historical expansion of matter's causal information domain - historic spacetime. Thus it is ultimately the spatial entropy drive of light's intrinsic motion which supplies the energy for the historical entropy drive of matter's time dimension. This energy cycle is completed by the gravitational conversion of bound to free energy (and the consequent conversion of the historical entropy drive of time to the spatial entropy drive of light) in the Sun and stars, and goes to finality in Hawking's "quantum radiance" of black holes.

Light is non-local, atemporal, acausal, massless, chargeless, and produces no gravitational field. Matter is local, temporal, causal, massive, charged, and produces a gravitational field. The conversion of globally symmetric light to locally asymmetric matter is succinctly characterized by matter's fundamental but local conservation parameters: mass, charge, time. (See: [The Tetrahedron Model](#) (diagram).)

The Doppler Effect and Related Phenomena

The magnetic field associated with an electric charge in relative motion transforms the motion of the charge's electrical field to an alternative electrical form (magnetism) which does not alter the original magnitude of the electric charge. The magnetic field functions to protect the invariance of electric charge in relative motion, hence also protecting charge and symmetry conservation. In an analogous fashion, the Doppler effect associated with a luminous object in relative motion functions to transform the motion of the light source to an alternative luminous form (color, frequency) which does not alter the magnitude of velocity c . The Doppler effect functions to protect the invariance of velocity c and hence also the conservation of energy and all things gauged by the universal electromagnetic constant. We have two invariant constants, electric charge and velocity c , both defended by effects related to their specific forms of duality or global-local translation: electric charge through the electric vs magnetic duality associated with the electromagnetic field, and velocity c through the wavelength vs frequency duality associated with the propagation of light. A magnetic field tells us an electrically charged particle is in relative motion, and the Doppler effect similarly informs us of the relative motion of any luminous object. Both effects are consequences of the "Lorentz Invariance" of Special Relativity, in which the local flexibility and covariance of time and space are necessary to maintain the global invariance of the "Interval", causality, and velocity c .

Related to these effects we note the fundamental quenching of an electric field by magnetic induction in the free electromagnetic wave, a balancing or compensation which results in the electrically neutral photon (a quantum unit of light), the field vector of the electromagnetic force. Sunshine - the common light of day - is another example, in this case produced by accelerated electric charges in the Sun. Electric charge remains invariant while the excess energy of acceleration is released as light and/or other forms of electromagnetic radiation. Here, electric charge and its field vector, the photon, work together as an embedded pair, maintaining charge invariance in a relative rather than an absolute environment. "Cherenkov radiation", synchrotron radiation, radar, medical x-rays, radio and TV, microwaves, are all related phenomena.

At the next level of material expression, we see the atomic combination of the electron and proton,

which also achieves electrical neutrality thanks to the magnetic field of the electron, despite the electron's orbital motion around the comparatively stationary proton. The universe is constructed in such a way (through global-local gauge symmetries and their transformations via the field vectors) that invariant constants derived from the spatial and absolute realm of light can nevertheless subsist in the relative, temporal realm of matter, although in an altered (but also invariant) form - charge. In their completely global or universal symmetric form, charges are directly related to light's symmetry through the virtual matter-antimatter particle pairs that light's energy constantly creates and annihilates throughout the spatial "vacuum". Similarly, material local charges are constantly in communication and equilibrium with their global counterparts through the swarms of virtual particles that surround them. Thus the separation between global and local energy forms, charges, and symmetry states is more apparent than real: the ideal forms remain with us.

Links

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[Principles of the Unified Field Theory: A Tetrahedral Model](#)

[\(Postscript and Commentary on paper above\)](#)

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[The "Higgs" Boson and the Weak Force IVBs: Parts II, III, IV](#)
["Dark Matter" and the Weak Force](#)

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