Global and Local Gauge Symmetries: Part IV

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John A. Gowan
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Global vs Local Gauge Symmetries: Material Effects of Local Gauge Symmetries

Abstract

"Local gauge symmetry currents" are forces that maintain the local invariance of universal constants and other conserved parameters (such as charge, causality, and the "Interval") despite the hostile environment of a variable gravitational (or inertial) metric, relative rather than absolute motion, entropy, partial charges, etc. These compensatory forces are due to the activity of the field vectors of the four forces, which not only act (in the long term) to return these asymmetric material systems to their original symmetric state (light), but also act (in the short term) to protect and maintain the invariant values of their charges (= symmetry debts) while awaiting a final repayment via antimatter annihilation, proton decay, the "quantum radiance" of black holes, or a universal "Big Crunch".

Preface

"Global vs local gauge symmetry" may sound like a forbidding technical concept, but it addresses a simple and powerful idea: in order to conserve energy, symmetry, charge, and causality, etc., certain constants of the "global" symmetric universe of light, space, and absolute motion must be maintained in the "local" asymmetric universe of matter, time, and relative motion. It is because we live in a universe compounded of both free and bound electromagnetic energy (light and matter), in which matter is an asymmetric form of (and derived from) light, that we need a concept such as global vs local gauge symmetry to address the conservation issues arising from this fundamental dichotomy in our energy forms and their interactions. The "global" parameters are universal constants such as the electromagnetic constant "c", and the gravitational constant "G", Planck's energy constant "h", the value of electric charge "e", etc. Similarly, the several charges of matter represent symmetry debts of light whose full values must also be protected. Included in the list of conserved invariants are such metric parameters as Einstein's "Interval" and the principle of causality, the latter addressed by the "Lorentz Invariance" of Special and General Relativity: the co-varying dimensions of space and time.

Parameters such as charge and velocity "c" are "global" in the sense that if we could change their value everywhere simultaneously, we wouldn't know the difference. However, variations in the value of these constants on the local scale, from one point to another (or from one day to another, or from one moving reference frame to another) would constitute a conservation disaster - from the point of view of causality, energy, symmetry, or charge conservation. Therefore, in the material realm of relative (rather than absolute) motion, where the energy of an atom or a material system varies with the relative motion of its reference frame, "local gauge symmetry currents" arise to protect the invariant value of charge, velocity c, and other global constants derived from the universe of light and space. Magnetic forces and the time/space dilations of Einstein's Special and General Relativity ("Lorentz Invariance") are premier examples, protecting electric charge, velocity c, causality and the "Interval", in moving (and gravitational) reference frames. The Doppler effect (in light) is a related phenomenon: the frequency of light emitted by a moving source changes, but not light's velocity. The production of all forms of electromagnetic radiation (including simple sunlight) by accelerated electric charges is an especially important example. The extra energy of accelerated motion is radiated away, leaving the electric charge unchanged. In the other forces, examples include permanent quark confinement via the "gluon" field in the strong force (protecting whole quantum units of charge) and the great masses of the Intermediate Vector Boson (IVBs) in the weak force (protecting the invariance of all conserved parameters of elementary particles (mass, charge, etc.).

Introduction: Charge Invariance

The principle of *charge invariance* is a common feature of both the "Tetrahedron Model" and the "Standard Model" of physics. *The charges of matter are the symmetry debts of light* (Noether's Theorem); if these debts are to be paid in full upon demand, charge invariance must hold in every system at all times. Consequently, charge magnitude and value must not be diluted or otherwise affected by inflation, entropy, relative motion, the expansion of the Universe, quark partial charges, particle transformations, distortions of the spacetime metric (gravitation), etc.

Charge invariance in the temporal realm of relative motion and atomic matter (vs the spatial realm of absolute motion and light) is the principle rationale for "local gauge symmetry". Charge invariance must be maintained in both the global (absolute) and local (relative) realm, typically by the field vectors of the forces (or their derivatives) which mediate interactions within and between these realms. Charge invariance is a corollary of charge and symmetry conservation, and ultimately, of energy conservation.

In the spacetime or "metric" forces (electromagnetism, gravitation, inertial forces), analogs of charge invariance take the form of the metric invariance of Einstein's "Interval", velocity c, and the invariance of the principle of causality ("Lorentz Invariance" - accomplished by the covariance of space and time in both Special and General Relativity). Two global or universal gauges are involved: 1) the universal electromagnetic constant "c", regulating the absolute global spatial metric, the intrinsic (entropic and "nonlocal") motion of light, and the invariance of causality and the "Interval"; 2) the universal gravitational constant "G", regulating (and modifying) the relative local spacetime metric (because gravity creates matter's time dimension). "G" introduces the explicit presence of time, which modifies, "warps", "curves", or produces a certain bias or inertial acceleration to the otherwise symmetric spatial metric, creating spacetime, the compound historical metric and domain of both free and bound electromagnetic energy. The local expression of "Big G" is "little g", which we experience as "surface gravity" (or forces of acceleration), and which varies from place to place within a given field (with altitude or with local concentrations of mass), and as the total field varies (for example) from planet to planet. Despite such variations in the spacetime metric, energy conservation is accomplished, the "Interval" and velocity "c" remain invariant, and causality is upheld, thanks to the local covariance of the dimensional parameters of space and time ("Lorentz

Invariance").

In the atomic or "particle" forces, the charge neutrality of cold, ground state atomic matter is a commonplace (if unappreciated) expression of local gauge symmetry. Charges are universal invariants, but they must also be translated into local invariants on an individual basis, for example, individual electrons must remain charge invariant in a temporal, 4-D world of relative motion. Charge neutrality is achieved in matter despite the relative motion of electrons in their atomic orbits (or elsewhere, thanks to magnetic forces), the partial charges of quarks (thanks to the gluon field), or the fact that protons and electrons are not each other's antiparticles (thanks to the weak force IVBs). Bosons (field vectors) of all the forces (gravitons, photons, IVBs, gluons) are their own antiparticles (either individually or as a group), an attribute necessary to their interactions with antimatter and virtual particles, as well as to their function as the force carriers or "currents" which translate invariant global gauge symmetries or charges ("location", electric charge, identity, color), into equally invariant local gauge symmetries or charges - and vice versa.

Phenomena of Local Gauge Symmetries

Whether or not we understand the full mathematical form of global vs local gauge symmetries (typically expressed through "group theory"), we can nevertheless appreciate some of the everyday consequences of the translation of global gauge symmetries into local gauge symmetries: our material world would be unrecognizable without them.

Electromagnetism

1a) Electromagnetic Force: magnetic rather than electric forces. Variable magnetic forces allow the existence of electron shells and the formation of atomic matter, with a variety of bond strengths rather than just one global electric bond strength (without magnetic forces, matter would exist only as an ionized plasma - chemistry of any kind would be impossible). Magnetism is the consequence of the relative motion of an electric charge or field. Variable magnetic fields complete the local gauge symmetry of electric fields in relative motion. Magnetic fields protect the invariant magnitude of electric charges in relative motion - the variable relative motion of an electric charge is expressed as a variable magnetic field rather than as variation in the value of electric charge. Similarly, the Doppler effect does not change the velocity of light, but instead changes light's frequency. The electrical neutrality of cold, ground state, crystalline atomic matter is a manifestation of the local gauge symmetry of electromagnetism, demonstrating the invariance of electric charges in relative motion (electron shells; moving electrons vs stationary protons). Both magnetic forces and the Doppler effect are part of the suite of relativistic effects associated with the covariance of space and time due to relative motion ("Lorentz Invariance" of special and General Relativity), protecting the invariance of velocity c, the "Interval", and causality, as well as the value of electric charge.

Electroweak Force

1b) Electroweak Force: mass rather than light: hν = mcc; bound energy rather than free energy. "Spontaneous symmetry-breaking" produces mass from the primordial interaction of the spacetime metric with the energy of light (as "gauged" or scaled by the "Higgs" Boson and mediated by the weak force IVBs). The return conservation loop is through matter-antimatter annihilation reactions. In the conversion of light to mass we begin to see the material consequences of the electroweak unification. (See: "The Higgs Boson vs the Spacetime Metric".)

The photon is its own antiparticle and is the field vector or boson of both the electric and magnetic fields. The duality in every force often includes the matter-antimatter duality, which is also the expression of duality on the cosmic level, touching the "multiverse". At cosmic scale, the multiverse is a global gauge expression, and our derived material Universe is a local gauge expression, conserving and processing energy and information in its own unique ("electromagnetic") way.

We might characterize the generalized rationale for the global-local divergence at the multiverse level as the creation of "something rather than nothing" - which also pertains to the energy fluctuations in the quantum-mechanical "vacuum". In "inflationary" theories, quantum energy fluctuations in the vacuum are the origin of our Universe, completing its fractal description. In these ideas we see the physical "vacuum" and analogous notions of the metaphysical "void" as expressions of a global gauge symmetry, or the multiverse, conceived in terms of pure creative potential. There may be many possible ("local") universes, all equally capable of energy conservation in their own way, no one to be preferred over another, except as it may or may not be "life friendly".

The electromagnetic force, electromagnetism, light, is the primary energy form of our Universe, and is associated with many fundamental dualities: electric and magnetic forces, the creation of spacetime, the creation (and annihilation) of matter-antimatter particle pairs, and free vs bound energy forms (light vs matter). The electromagnetic constant "c", the "velocity of light", is the master global gauge energy constant, implicitly or explicitly involved in all four forces. All charges, forces, and masses are derived from light and eventually return to light via matter-antimatter annihilations, fusion or fission, particle and proton decay, or various astrophysical processes (stars, quasars, supernovas, etc.) including Hawking's "quantum radiance" of black holes. (See: "Symmetry Principles of the Unified Field Theory".)

Weak Force

2) Weak Force: asymmetry vs symmetry - charge conservation vs symmetry conservation. *The charges of matter are the symmetry debts of light*. The creation and transformation of matter: the decay and transformation of neutral leptoquarks (to mass-carrying baryons and charge-carrying leptons) proceeds via the weak force "IVBs" (Intermediate Vector Bosons: the "X" and the "W+", "W-", "Z"), including the virtual particle-antiparticle pairs of the Heisenberg-Dirac vacuum of spacetime, and via various fields of alternative charge carriers - the leptons, neutrinos, and mesons. The role of the IVBs and the Higgs boson is the creation of unified force-symmetry states (such as the electroweak force-unity state) in which elementary particles with invariant mass and charge may be created and/or transformed, protecting charge, symmetry, and energy conservation. Within these force-unity symmetry states, the IVBs (gauged by the Higgs boson) make available vacuum charges and alternative charge carriers to various real particles, allowing transformations, decays, and the creation and destruction of single elementary particles. (See: "The 'W' IVB and the Weak force Mechanism".) The weak force establishes charge conservation (via massive charge-carrying particles) as an alternative (temporal, historical) form of symmetry conservation; otherwise we would have only a Universe of light and matter-antimatter (virtual particle) annihilations. (See: "The Origin of Matter and Information"; see also: "The Higgs Cascade".)

The role of the weak force is the creation and transformation of (single) elementary particles carrying "identity" charge, including the creation, destruction, and swapping (exchange) of elementary charges and associated mass-energy conserved quanta. Just as charge invariance is a critical issue for charge and symmetry conservation, so also must be the mechanism of elementary charge carrier creation/transformation (creation/transformation of quarks and leptons). The role of the weak force and the massive IVBs is to ensure that charge invariance, charge conservation, and energy conservation are all scrupulously observed in any creation/transformation of (single) elementary particle charge, mass, and identity. To this end, the massive IVBs provide a "conservation containment" or "safe house" in which charge and energy can be transferred between "real" and virtual particles in very close proximity (perhaps essentially "touching" each other), such that no conservation laws are threatened or actually broken by risky long-range transfers. (See: "The 'W' IVB and the Weak force Mechanism".) These interactions can perhaps be better understood as reprising the original "Big Bang" symmetry state of the electroweak force unification realm in which all such transformations are but the normal course of affairs. That is, the "safe house" of the IVBs is the symmetry state of electroweak force unity, in which particle "identity" or "flavor" charge exists at a generic rather than a specific level. (See: "The Higgs Boson and the Weak Force IVBs".)

The weak force IVBs are "metric" particles, catalytic particles composed entirely of a densely compressed and (perhaps) convoluted metric, probably similar to the densely energetic and compressed primordial metric of the early "Big Bang". The great mass of the IVBs consists of the binding energy required to compress and maintain a volume of spacetime metric into the IVB configuration and density. (See: "The Weak Force IVBs as a Bridge Between 2-D and 4-D Reality".)

The most significant feature of the massive IVBs is that they recreate the original conditions of the energy-dense primordial metric in which particles were created and transformed during the early micro-moments of the "Big Bang" (the "W" IVB family recreates the electroweak era; the "X" IVB family recreates the GUT era). This recapitulation ensures that the original and invariant values of charge, mass, and energy are handed on to the next generation of elementary particles in the charge-transfer chain. The IVB mass not only provides a "conservation containment" or "safe house" where charge and energy transfers can take place, it simultaneously ensures that the appropriate alternative charge carriers (leptons, neutrinos, mesons) are present (derived from the Heisenberg-Dirac spacetime vacuum). (See: "The 'W' IVB and the Weak force Mechanism".)

There is a crucial difference between the electromagnetic or strong force creation of particle-pairs via symmetric particle-antiparticle formation, and the weak force creation or transformation of asymmetric "singlet" particles to other elementary forms. ("Singlets" are matter particles without antimatter "mates".) In the case of particle-antiparticle pair creation, there can be no question of the suitability of either partner for a subsequent annihilation reaction which will conserve their original symmetry. Both particles are referenced against each other and gauged or scaled by universal electromagnetic and metric constants such as c, e, and h. However, in the case of the weak force creation or transformation of a "singlet" elementary particle to another form, alternative charge carriers must be used to balance charges, since using actual antiparticles for this purpose can only produce annihilations. But how can the weak force guarantee that the alternative charge carriers - which may be a meson, a neutrino, or a massive lepton - will have the correct charge in kind and magnitude to conserve symmetry at some future date in some future reaction, or with an unknown partner which is not even its antiparticle? Furthermore, quark charges are both partial and hidden (because they are "confined"), and number charges of the massive leptons and baryons are also hidden (because they are *implicit*) - they have no long-range projection (such as the magnetic field of electric charge) to indicate to a potential reaction partner the relative condition of their energy or charge state. Conservation of energy, charge, and symmetry require that elementary particles created today, tomorrow, or yesterday be exactly the same in all respects as those created eons ago in the "Big Bang". (See: "Introduction to the Weak Force".)

These conservation problems are all solved by a return to the original conditions in which these particles and transformations were first created, much as we return and refer to the Bureau of Standards when we need to recalibrate our measuring instruments. The necessity for charge invariance in the service of symmetry conservation therefore offers a plausible explanation for the otherwise enigmatic large mass of the weak force IVBs. Weak force "singlets" can only be referenced against their original creation energy, as scaled by the universal Higgs boson. The IVB mass serves to recreate the original environmental conditions - metric and energetic, particle and charge - in which the reactions they now mediate took place, ensuring charge invariance and hence symmetry conservation regardless of the type of alternative charge carrier that may be employed. (See: The Higgs Boson and the Weak Force IVBs.)

In function, the mass of the IVBs constitute the weak force analog of the magnetic field of the electromagnetic force. IVBs mediate the "local gauge current", while the particle-antiparticle pairs of the spacetime vacuum "zoo" comprise the "global gauge symmetry" in terms of charge magnitudes, which must be the same universally. The IVBs form a bridge between the global virtual "zoo" and local "real" (temporal) particles, accessing the charges of the "zoo" so the real particles can undergo transformations and decays. The "current" is the flow of virtual particles (in both directions) between the global "zoo" and the local particles as mediated by the IVBs; the real particles themselves display the local gauge symmetry, transformed massive, temporal particles which nevertheless carry globally invariant charges. The local symmetry is manifest as the perfect balancing of charges, achieved despite the differing ages, histories, species, and relative motions of the particles. The return conservation loop (matter back to light) is accomplished through various routes, including particle-antiparticle annihilation, particle and proton decay, and astrophysical processes in stars, etc. (the gravitational conversion of bound to free energy). (See: " The Weak Force IVBs as a Bridge Between 2-D and 4-D Reality".)

The charge specifically associated with the weak force is "identity" (also known as "number" or "flavor" charge), carried in explicit form by neutrinos and in "hidden" or suppressed form by leptons and the (hypothetical) leptoquark. The hidden form of the identity charge is another rationale for the mass of the IVBs as a local compensatory response; the mass of the IVBs is the weak force analog of the magnetic field of electric charge, equilibrating the hidden charges of the massive leptons and the explicit charges of the (nearly) massless neutrinos - so that charge balancing and/or annihilation can occur. (See: "Identity Charge and the Weak Force".)

Phenomena associated with weak force particle transformations include the creation of matter during the Big Bang, radioactivity, fission, particle and proton decay, contributions to element building and the nucleosynthetic pathway in stars, supernovas, etc. (See: "The Particle Table".)

Strong Force

3) Strong Force: Partial charges (the local gauge symmetry) rather than whole quantum unit charges (the global gauge symmetry); (quarks, gluons, color charges, and baryons vs leptons; composite vs elementary particles; electrically neutral composite particles vs electrically charged elementary particles). Partial charges include a variety of charge species carried by the quarks (electric, flavor, color, spin) - allowing the creation of electrically neutral leptoquarks and baryons (such as neutrons). Electrical neutrality permits the creation of matter via the asymmetric decay of electrically neutral leptoquarks (which otherwise would be instantly annihilated by their electrically charged antimatter partners). Partial quark charges are permanently confined to whole quantum unit charge combinations (baryons and mesons) by the gluon field, composed of color-anticolor pairs in eight different combinations, all moving at velocity c (gluons have been compared to "sticky" light because unlike photons, they attract each other).

The global condition (whole quantum unit charges which are universally the same - as in the elementary leptons) will not permit the creation of matter because electrically neutral mass carriers cannot be formed (electrically charged massive particles are immediately annihilated by their oppositely charged antimatter partners - fulfilling the global symmetry-keeping function of electric charge and the photons (field vectors) of the electromagnetic force, as required by "Noether's Theorem"). However, partial charges carried by the quarks can form electrically neutral combinations (such as the familiar neutron). The creation criterion of electrical neutrality is why the primordial mass carrier (the baryon) must be a composite particle. Electrically neutral leptoquarks have time to undergo individual leptonic (weak force) decays, independently of their electrically neutral antimatter partners, producing in the asymmetric decay process a tiny excess of matter over antimatter (see: "The Origin of Matter and Information").

In "proton decay", the "X" IVB of the weak force (GUT energy level) compresses the gluon field to its original leptoquark configuration, squeezing the color-anticolor charges of the gluon field until they physically sum to zero and self-annihilate (the limit of "asymptotic freedom"), allowing again a leptonic decay and restoring the original global symmetries of leptonic unit charge and massless light. The leptonic whole unit charge (electric charge and "number" or "identity" charge) is the global gauge symmetry (of Noether's Theorem and charge conservation), the partial charges of the quarks are the derived local gauge symmetry (summing to unit charge), the gluon field (the field vector of color charge) is the local gauge symmetry "current" or force, permanently confining the partial charges of the quarks to whole quantum unit values. Electric charge is universally interchangeable, and identity charge is interchangeable within an elementary particle species (all electrons are identical, etc.); these are global symmetries. All quarks are interchangeable with respect to color charge (global symmetry); quark partial charges sum to unit leptonic charges and "white" color despite their differing "flavors" (u, d) and other fractionally charged states (local symmetry). Proton decay closes the charge symmetry and energy conservation loop (leptoquark -> baryon -> leptoquark; light -> mass -> light; symmetry -> charge -> symmetry).

Phenomena associated with the strong force include: sunshine and starlight - nuclear fusion - and the elements of the periodic table (meson exchange field - see below). The nucleosynthetic pathway - element building in the stars - is the first (gravitational) step toward the return of matter to its original form, light. The process goes to completion in Hawking's "quantum radiance" of black holes. "Quantum radiance" completes the symmetry circuit beginning with light, devolving to matter through the conserved charges of the electric and nuclear forces, and finally back to light again through fusion and ultimately "quantum radiance". (Another strong force conservation circuit goes to completion through the alternative route of proton decay (gluon exchange field - see above). Proton decay may be commonplace in the interior of black holes.) (See: "The Half-Life of Proton Decay and the 'Heat Death' of the Universe".)

The Strong Force - Two Expressions

(See: "The Strong Force: Two Expressions".)

Gravity

The problem: How to create a metric containing negative energy that does not violate energy conservation or the invariance of velocity c, the "Interval", or causality? The solution: Reverse the entropy drive of the metric from expansive to contractile, via the creation of time from metrically equivalent space. Allow the dimensional parameters to co-vary ("Lorentz Invariance"), such that velocity c, etc., remains invariant. Center the field symmetrically upon massive particles, so that it vanishes at the center of mass, imparting no net velocity to its source.

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4) Gravitational Force: The creation of time from space; the creation of spacetime and the historic domain of matter's causal information field; "Lorentz Invariance" in General Relativity - the covariance of space and time in gravitational fields; intrinsic motion in time rather than space (mass vs light); negative vs positive energy and entropy; temporal vs spatial entropy drives; many asymmetric local metrics vs one symmetric global metric (g vs c).

Gravitational phenomena: the earth, the solar system, the galaxy, planets, stars, astronomical phenomena of all kinds - supernovas, quasars, black holes, the "Big Bang" and the "Big Crunch". Time and historical spacetime - cosmic spatial deceleration. Relative motion rather than absolute motion; energy conservation within an historic, local (spacetime) metric rather than within a purely spatial, global metric. Velocity c, the "Interval", and causality are all maintained and protected by "Lorentz Invariance" in its General Relativistic mode, the covariance of time and space in accelerated or gravitational reference frames and systems.

Gravity: time; many different local spacetime metrics (gauged by "g") rather than only one (the single global spatial metric gauged by c). Many different clock rates, local accelerations ("little g"), many different planets and star sizes, galaxies, etc. The local metrics of gravity (g) are all variations of the global metric (c), with energy debited from the expansion of space (which is used for the creation of time and the historical domain), causing in consequence the gravitational deceleration of the cosmic spatial expansion. This energy is (eventually) returned by the gravitational conversion of bound to free energy in stars and finally by Hawking's "quantum radiance" of black holes. The metric of light is primary and global, the metric of gravity is secondary, derived, and local. The conservation loop is from the gravitational deceleration of cosmic spatial expansion, through stars, and back to the spatial expansion of the Universe via the gravitational conversion of bound to free energy (seen today as the recently discovered "acceleration" of the cosmic expansion).

When g = c, at the "event horizon" of a black hole, we find matter returned to the original inertial state of light: matter moves at velocity c, time stands still, meter sticks shrink to nothing, etc., and the temporal entropy drive of matter completely replaces the spatial entropy drive of light. Inside the event horizon, proton decay completely converts matter to light; outside the event horizon, Hawking's "quantum radiance" converts gravitational bound energy to electromagnetic free energy, eventually converting the entire mass of the black hole to light.

The global symmetry expression is light, which has intrinsic motion in space (gauged by "velocity c"), actually creating and expanding space by its own intrinsic motion. Light is the only energy form which creates its own conservation domain out of its own nature (the "intrinsic" motion of light, the entropy drive of free energy). The local symmetry is gravity, gauged by "velocity G", which regulates the conversion of space and the intrinsic motion of light (the expansive entropy drive of space and free energy) to history and the intrinsic motion of time (the expansive, one-way entropy drive of bound energy's time dimension). Time is the active principle of gravity's "location" charge. Gravity creates time via the annihilation of space. *A gravitational field is the spatial consequence of the intrinsic motion of time*. Gravity is the inversion of the entropy/symmetry drive causing light's intrinsic spatial motion (see: "Gravity Diagram No. 2".)

Gravity connects back to the global symmetry of light in (at least) three ways:

> 1) Decelerating the light-driven expansion of the Cosmos - paying the entropy-"interest" on the symmetry debt of matter by creating the intrinsic motion of matter's time dimension and historical domain from energy supplied by the intrinsic motion of light's spatial domain. Charge conservation = symmetry conservation *in the time dimension*. Time is supplied by the gravitational conversion/annihilation of space.
> 2) The nucleosynthetic pathway and the "quantum radiance" of black holes. Return of bound energy to free energy, paying the energy-"principle" on all symmetry and entropy debts of matter and bound energy.
> 3) The negative gravitational energy of mass exactly balances the positive rest mass energy of matter - allowing the creation of matter from zero net energy - as a quantum mechanical fluctuation of the vacuum (in the "Big Bang" - perhaps as in the "inflationary" theory of Alan Guth, Linde, and others (?)).

Light produces a single universal metric symmetry; gravity produces many local metric asymmetries of various magnitudes and intensities. Nevertheless, all gravitational (spacetime) metrics conserve energy and protect the invariance of velocity c, Einstein's "Interval", and causality, regardless of the magnitude of the local "warpage" - due to the covariance of space and time, and the perfectly spherical overall or net symmetry of any gravitational field. The covariant current of space and time (the gravitational force field), is the "local gauge symmetry current" which vanishes when we move with the flow - as also seen in the case of magnetic fields, and in the "asymptotic freedom" of the strong force gluon field. All "local gauge symmetry currents" maintain the local invariance of globally conserved charge and metric parameters. Likewise, all differences between the various quark or lepton flavors vanish in the unified force symmetric energy state created by the huge mass of the weak force IVBs (specific differences are subsumed in generic unity).

The energy to produce matter's time dimension comes from the gravitational deceleration of the spatial expansion of the Universe, so it is ultimately the expansive energy (entropy drive) of light and space which funds the expansive energy (entropy drive) of matter's time dimension and historical spacetime. The energy/entropy/symmetry circuit between the parental (global) metric gauge symmetry (c) and the derived local metric gauge expression (g) is completed by the gravitational conversion of bound to free energy, as in stars. The radiance of our Sun is the expression or announcement of a completed symmetry circuit. Spatial vs historical expansion is also linked (through entropy) as the implicit vs explicit expression of time. (See: "Currents of Symmetry and Entropy" and "The Conversion of Space to Time".)

The weakness of gravity is due to the tangential connection (the "present moment") between matter and its historical conservation domain (historic spacetime). This tangential connection is due to the fact that it is matter's time dimension, and not matter itself, that has intrinsic, entropic historical motion (the metric equivalent of light's intrinsic, entropic spatial motion, both gauged by "velocity c"). Matter has no (net) intrinsic motion in either space or time, although its associated gravitational field (Gm) consumes space to produce time. Matter's gravitational field represents matter's primordial, intrinsic entropy drive, producing matter's moving time dimension via the annihilation of a metrically equivalent quantity of space. The separation between matter and its historical conservation domain is the root cause of human anxiety regarding our fleeting experience of life, but is necessary to protect both the energy and charge of atoms from the vitiating action of temporal entropy (aging). In consequence, atoms retain the full value of their energy content and charge magnitude until their energy and symmetry debts are paid in full, for the age of the Universe, if necessary. "Diamonds are forever".

The negative energy of gravitation exactly balances the positive energy bound in mass (a realization attributed to Pascual Jordan). Because this same negative gravitational energy decelerates the positive, expansive energy of the Cosmos, we begin to understand how it is that the expansive and contractile energies of the Universe are so nearly balanced (the geometry of the Universe is "flat"). In the "Big Bang", positive energy and negative gravitational energy were in exact balance, so the Universe "cost" nothing to produce, essentially as a gigantic quantum mechanical fluctuation of energy in the "void". Since that beginning, a lot of matter has been converted into light, and no new matter has been created. Since light produces no gravitational field but matter does, this conversion (by stars, quasars, supernovas, particle fission and fusion, etc.) has the effect of reducing the total mass of the Cosmos and its associated gravitational field. (The conversion of bound to free energy presumably also occurs in "dark matter", in observance of the usual conservation laws.) This continuous mass and gravitational loss produces the impression that the expansion of the Universe is "accelerating", whereas in fact it is simply decelerating less and less rapidly. (See: " A Spacetime Map of the Universe" and "A Description of Gravity".)

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