Gravity, Entropy, and Thermodynamics: Part I
(revised July, 2014)

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Gravity is Matter's Memory it Once was Light

Table of Contents (part I)

(I recommend the reader consult the "preface" or "guide" to this paper, which may be found at "About the Papers: An Introduction" (section 7); also "Section 2: An Introduction to Gravitation").

Part I

Go to Part II

Abstract

The intrinsic motions of light, time, and gravity are primordial forms ("drives") of entropy, causing: 1) the creation, expansion, and cooling of space; 2) the creation, expansion, and aging of history; 3) the creation of historic spacetime, respectively. *The charges of matter are the symmetry debts of light* (Noether's Theorem). Gravity pays the entropy-"interest" on matter's symmetry debt by creating time from space - giving charge conservation an extended, causal significance in the time dimension. Light's spatial entropy drive and expansion funds matter's historical entropy drive and expansion, via the gravitational conversion of space to time; cosmic spatial expansion decelerates in consequence. Gravity pays the energy-"principal" of matter's symmetry debt by the conversion of bound to free energy - via the nucleosynthetic pathway in stars and supernovas, via the conversion of gravitational potential energy to radiation in quasars, and via Hawking's "quantum radiance" of black holes. The global gravitational energy field is reduced as mass is converted to light; cosmic spatial expansion accelerates in consequence.

In the mathematical terms of Evariste Galois' "Group Theory", the "Tetrahedron Model" is a description of the symmetry group of light, including its destruction by asymmetric weak force decays (producing our matter-only Cosmos), and its on-going restoration in obedience to Noether's Theorem of symmetry conservation (as in the conversion of bound to free energy in stars).

Introduction

Gravitation produces a local, spacetime metric for massive matter (gauged by Newton's universal gravitational constant "G"), imposed upon (and derived from) a global, spatial metric for massless light (gauged by the universal electromagnetic constant "c"). The spacetime metric of gravitation - like the spatial metric from which it is extracted - exists for several related conservation imperatives. In the gravitational case, these imperatives include: 1) The conservation of energy (1st law of thermodynamics); 2) entropy (2nd law of thermodynamics); 3) causality (the law of cause and effect); 4) the conservation of symmetry (Noether's Theorem). In the material/gravitational universe, entropy, causality, and the conservation of symmetry are necessary adjuncts to the conservation of energy. Entropy, causality, energy, and symmetry conservation are all related through the universal electromagnetic gauge constant "c" and the intrinsic motion of light. Among other functions, "velocity c" regulates or "gauges" the primordial spatial entropy drive of light; the metric symmetry of space; Einstein's "Interval" and causality, including "Lorentz Invariance"; the energetic relation between bound and free energy (mass vs light): E = mcc; and the symmetric "non-local" distribution of light's energy throughout space. (See: "The Tetrahedron Model".)

The rationale for gravity begins with the creation of the Cosmos - the negative energy of gravity is necessary to balance the positive energy of the "Big Bang", so that the "Creation Event" requires zero net energy. This is the time when gravity is joined with the other forces in equal strength, and bound energy (mass) is created from free energy (light) and the structural metric of spacetime through the combined action of the four forces of physics. Initially, bound energy is in the form of matter-antimatter pairs, so that creation is initiated from a state of zero net charge as well as zero net energy. Beginning in such a state of complete neutrality (perhaps as a giant quantum fluctuation of the vacuum, an "inflationary bubble", or by Divine Fiat), the Universe can only subsequently evolve into a state of complete conservation. (While such a huge quantum fluctuation might be unthinkable in our own universe, it might not be so unusual in the Multiverse - we simply don't know. In any case, all "creation" scenarios are speculative, whether rationally or intuitively motivated.)

Following on from its primary role of providing negative energy during the "Big Bang", gravity plays (at least) two further major conservation roles in the evolving universe: 1) the conversion of space to time (the role we see on Earth); 2) the conversion of bound to free energy (in stars, supernovas, quasars, and via Hawking's "quantum radiance" of black holes). The first role conserves the entropy drive ("intrinsic motion") of light (free electromagnetic energy); the second role conserves light's "non-local" distributional and metric symmetry (obeying Noether's Theorem). These secondary conservation roles are natural consequences of the mode of action of gravity's primary role, which is the creation of negative energy and entropy via the contraction and destruction of space (creating time), in contradistinction to the expansion and creation of space by the positive energy and entropy drive of light.

Gravity satisfies its energy, entropy, and causality conservation role immediately and directly, through the creation of time - via the annihilation of space and the extraction of a metrically equivalent temporal residue (see: "The Conversion of Space to Time"). Time serves as the primordial entropy drive of bound energy, and also protects Einstein's "Interval" (via "Lorentz invariance" and the covariance of time with space) - conserving the principle of causality in material systems with relative rather than absolute motion. Time is also necessary to accommodate the energy accounts of matter in relative motion. The intrinsic motion of time produces history, the conservation domain of matter's causal information matrix, web, or network (historic spacetime). The spherically symmetric gravitational field vanishes at its center, not only producing time by the annihilation of space, but also ensuring that no net spatial motion accrues to the gravitating mass (observing energy conservation). (See: "Global-Local Gauge Symmetry in Gravitation".)

Gravity satisfies its symmetry conservation role through the conversion of bound to free energy (in stars, for example), but is in no hurry to do so. The symmetry debts of massive particles, which are generally held through time in the form of conserved charges, may be paid or discharged on an indefinite schedule - unlike energy conservation debts, which must be paid immediately (as in the inertial and entropic conservation functions of gravitation). Gravitational symmetry debts are paid by the conversion of bound to free energy - mass to light - in stars, supernovas, and quasars. The process goes to completion in Hawking's "quantum radiance" of black holes. This final and complete gravitational conversion of mass to light pays all matter's energy, entropy, and symmetry debts simultaneously. Matter's gravitational field vanishes as matter itself vanishes, providing the evidence that the symmetry debt represented and carried by matter's gravitational charge and field has been fully repaid. (See: "Does Light Produce a Gravitational Field?")

Inertial forces arise as metric symmetry debts which behave like raw energy debts, unlike the symmetry debts of massive particles which are held through time in the form of charges. A fundamental difference therefore characterizes spatial (inertial) vs temporal (material) symmetry debts. Gravitation bridges this distinction, however, converting the spatial entropy drive of light (the intrinsic motion of light, which is wholly inertial in character) to the historical entropy drive of matter (time's intrinsic motion, which is partly inertial and partly charge-like in character (because time is an asymmetric, one-way, local, metric symmetry debt always attached to some form of bound energy). The unfavorable conversion from symmetric space to asymmetric time results in the negative sign of "G": (-Gm), and energy is immediately debited from the spatial expansion of the Cosmos. Thus gravitation has both a spatial, inertial character as a symmetry debt, and a temporal, charge character as an entropy debt. The gravitational "location" charge, whose active principle is time, connects spatial with temporal metrics, symmetry conservation with entropy conservation, and gravity with the other charges and forces of physics through "Noether's Theorem": *the charges of matter are the symmetry debts of light*. Time is the entropic charge of the gravitational force. *A gravitational field is the spatial consequence of the intrinsic motion of time*. Time and gravity induce each other in an endless entropic conservation loop. (See: "The Conversion of Space to Time"; see also: "The Double Conservation Role of Gravitation".)

The gravitational symmetry debt is in response to the broken symmetry of light's "non-local" distribution in space, when light is converted to any form of bound energy. The gravitational entropy debt is in response to light's lost intrinsic motion, arising from the same cause and simultaneously with the symmetry debt. The gravitational charge is designated "location"; time is the active principle

of gravity's "location" charge. Time's intrinsic (entropic) historic motion replaces light's intrinsic (entropic) spatial motion; the time dimension specifies the 4-dimensional location of immobile, undistributed matter, and as these charges are summed and concentrated, the total amount and density of bound energy as well.

The ultimate purpose of a dimensional metric, whether spatial and global (as gauged by "c"), or temporal and local (as gauged by "G"), is the conservation of energy. This role is fulfilled by gravitation through the production of bound energy's time dimension via the annihilation of space and the extraction of a metrically equivalent temporal residue. Gravity converts light's spatial metric and entropy drive (the intrinsic motion of light) into matter's historical metric and entropy dive (the intrinsic motion of time). The simple entropic expansion and cooling of space is gravitationally converted to the compound entropic expansion and aging of historic spacetime.

Gravity (immediately) pays the entropy-"interest" on matter's symmetry debt by extracting time from space, in consequence decelerating the cosmic spatial expansion (hence cosmic historical expansion is funded by and replaces cosmic spatial expansion). Gravity (eventually) pays the energy-"principle" of matter's symmetry debt by converting bound to free energy in stars, supernovas, quasars, and by Hawking's "quantum radiance" of black holes, actually reversing the contractile effect of its entropy conservation role and causing an "acceleration" of the cosmic expansion (due to a reduction in the total gravitational energy of the cosmos) - as recently observed. (See: "Does Light Produce a Gravitational Field?"; and "Global-Local Gauge Symmetries in Gravitation").

Four Physical Principles

In this paper I will examine the role of gravitation in the context of 4 physical principles (conservation laws and their corollaries): energy conservation, entropy, causality, and symmetry conservation.

The first law of thermodynamics asserts the conservation of energy: in any isolated system, the total energy remains the same, regardless of transformations. The second law of thermodynamics concerns entropy: in any isolated system, the capacity for "work" by that system must decrease (or at the very least, not increase) over time, as by expansion and/or cooling. (Historical expansion is also entropic due to aging, decay, and the dilution of causal linkages.)

According to standard formulations of the subject, three conditions characterize the change of entropy within an isolated system [1]:

1) the change in entropy depends only upon the difference between the initial and final states of the system;
2) in reversible systems the entropy change is zero;
3) in irreversible systems the entropy change is positive.
(See: "Spatial vs Temporal Entropy".)

In addition to causality (the law of cause and effect) and the first and second thermodynamic laws, the "Tetrahedron Model" requires a 4th conservation principle, the conservation of symmetry, which is not a thermodynamic law, but is nevertheless related to causality and both the first and second laws in significant ways. This principle of conservation was mathematically formulated (1918) by Emmy Noether and is known as "Noether's Theorem". It states that in a continuous multicomponent field,

such as the electromagnetic energy field (or the metric field of spacetime), whenever we find a symmetry we will find an associated conservation law, and vice versa: conservation laws have associated symmetries. Hence symmetry's relationship to the first law of thermodynamics. I like to think of Noether's theorem as the "truth and beauty theorem", for it is essentially a mathematical translation of Keats' profound poetic intuition (1819) that "Beauty is truth, truth beauty...", where truth is conservation and beauty is symmetry [2].

Symmetry conservation is also related to the second law of thermodynamics because symmetric systems generally have greater (positive) entropy than asymmetric systems; hence symmetry conservation drives toward higher entropy states (random states are highly entropic, highly probable, and highly symmetric). This is especially evident in the tendency of all forces to convert bound energy to free energy, as light has both the greatest symmetry and the greatest positive entropy of any energy form. Stellar nucleosynthetic processes, supernovas, quasars, and Hawking's "quantum radiance" of black holes are specific examples of entropic systems of lesser symmetry (matter and time) being spontaneously converted to entropic systems of greater symmetry (light and space). The complete gravitational evaporation of black holes is the ultimate expression of "Noether's Theorem", in which it is demonstrated that even the symmetry of entropy is conserved.

Symmetry conservation is most familiar to us in the guise of charge (and spin) conservation, since *the charges of matter are symmetry debts of light*, debts incurred during the conversion of symmetric light to asymmetric matter during the "Big Bang" (or in any subsequent process converting free to bound energy). The "inertial" forces of the spacetime metric are another familiar example of Noether's theorem enforced in Nature, and of the relation between symmetry and energy conservation. (See: "Symmetry Principles of the Unified Field Theory".) The principles of entropy and symmetry conservation are also physically connected by the phenomena of both light and gravitation. The electromagnetic constant c (the "velocity of light"), is the "gauge" (regulator, scale factor) of both light's symmetric "non-local" energy state and light's entropy drive, as light's intrinsic motion is an expression of both - creating, expanding, and cooling space on the one hand (the entropy drive), while simultaneously suppressing the temporal dimension, maintaining metric symmetry, and establishing the "non-local" distribution of light's energy throughout spacetime on the other hand (the symmetry gauge). In turn, gravitation is both conserving light's entropy drive in the conversion of light's expansive spatial domain to matter's expansive historical domain, and conserving light's "non-local" symmetric energy state in the conversion of bound to free energy (as in stars, supernovas, quasars, and Hawking's "quantum radiance" of black holes).

Pure and Mixed Forms of Entropy

Spatial, "Thermal", or "Work" Entropy vs Temporal, "Cold", or "Stored" Entropy
See: "Spatial vs Temporal Entropy".

Entropy exists in several forms in nature, always with the same purpose, to prevent violations of energy conservation. Unless the context indicates otherwise, when I refer to "entropy" in these papers (especially in such phrases as "space and the drive of spatial entropy" or "time and the drive of historical entropy"), I am referring to entropy in its most primordial or pure form, as the "intrinsic motion" of light "gauged" or regulated by "velocity c" (causing the expansion and cooling of space in the case of "spatial entropy"), or as the "intrinsic motion" of time, gauged or regulated by "velocity T"

(causing the expansion and dilution of history or historic spacetime in the case of "temporal entropy"). "Velocity T" is itself gauged by "c": the electromagnetic metric of empty spacetime is gauged by the universal electromagnetic constant "c", such that one second of temporal duration is metrically equivalent to 300,000 kilometers of spatial distance (approximately).

Thermal or "work" entropy, as generally defined, is the energy in an isolated system which *on principle cannot be transformed to work*. Entropy characterizes the degradation of energy inherent in the operation of any cyclic engine or process of energy transformation, typically manifest as "heat loss": the same energy cannot be used twice to produce the same net work. These ideas imply the conservation of energy and the impossibility of a "perpetual motion machine". Entropy is a corollary of - and a principle safeguarding - energy conservation, allowing the transformation of energy. Entropy prevents the abuse of energy; without the principle of entropy, energy conservation would prevent any use or transformation of energy at all.

"G" (the universal gravitational constant) gauges the strength of the connecting link or conversion factor between the primordial forms or "drives" of spatial and temporal entropy: gravity converts space and the embedded drive of spatial entropy (the intrinsic motion of light) to time and the embedded drive of historical entropy (the intrinsic motion of time). Whereas the electromagnetic constant "c" is the gauge of the *metric* relation between space, time, and free energy (light), the gravitational constant "G" is the gauge of the *entropic* relation between space, time, and bound energy (mass). When free energy is converted to bound energy, the entropy-energy driving the spatial expansion of the universe is gravitationally converted to the entropy-energy driving the historical expansion of the universe; in the process, space is gravitationally annihilated, decelerating the spatial expansion accordingly (and thereby providing the energy for the historical expansion - which requires an extra dimension). (See: "A Description of Gravitation"; see also: "A Spacetime Map of the Universe".)

So essential is the connection between entropy and energy conservation that entropy is an embedded physical characteristic of energy ("primordial" entropy drives as gauged by c, T, and G). "Primordial" entropy drives are expressed as the intrinsic motion "c" of free energy (the velocity of light - primary mode), and as the intrinsic motion "T" of bound energy's time dimension (the metric equivalent of velocity c - secondary mode). These two "primordial" entropy drives are connected by gravitation, which converts one into the other (in either direction), sometimes performing both conversions simultaneously, as in the solar conversion of space to time (entropy conservation), and mass to light (symmetry conservation). The intrinsic motions c, T, and G are all physical expressions of entropy embedded in their energy forms (free and bound electromagnetic energy).

The effectively "infinite" velocities of both light and time are necessary attributes of their role as the entropy (and causality) drives of free and bound energy. These "infinite" velocities guarantee the increase of spatial and historical entropy, while simultaneously preventing violations of energy conservation and/or causality via fast spaceship or "time machine". Hence these intrinsic motions also effectively close and protect the borders of the dimensional conservation domains they create (space, history). The dimensions of spacetime are conservation domains created by the primordial entropy drives of electromagnetic energy - whether free energy (light and space) or bound energy (matter and history). Similarly, gravitation closes the borders of its composite spacetime domain via the "event horizon" and central "singularity" of black holes, likewise preventing conservation violations (perhaps

via intrusive "wormholes", or via the leakage of energy into or from other dimensions or universes). In the black hole, gravity takes over the entropic functions of both c and T - "freezing" light and time - just as gravity takes over the molecular and nuclear binding functions of atomic matter. (Within the "event horizon", the gravitational metric of bound energy functionally and completely replaces the electromagnetic metric of free energy, including causal and entropic relations.) Proton decay (probably) takes place at the central singularity, and (if so) the black hole is filled with gravitationally bound light, the extreme limit of the gravitational metric and the temporal entropy domain. Inside the black hole, matter becomes co-extensive with its temporal domain, just as outside the black hole, light is co-extensive with its spatial domain. We can therefore also expect that matter will become subject to vitiating forces of temporal entropy inside the hole, just as light is subject to vitiating forces of spatial entropy outside the hole. This expectation (among other considerations) leads us to expect that proton decay is commonplace inside black holes.

"The extremes meet": the black hole is the extreme form of the gravitational/temporal metric of bound electromagnetic energy, just as empty space is the extreme form of the electromagnetic/spatial metric of light. But in both cases, all forms of energy move at "velocity c" within their respective metric domains (because in the black hole g = c) - hence both represent actual symmetric energy states - one positive/spatial and one negative/temporal. Which state is gravity actually driving toward? The black hole, or Hawking's quantum radiance? (See: "Nodes of the Gravitational Metric".)

The gravitational conversion of space and the drive of spatial entropy to time and the drive of historical entropy is physically demonstrated by black holes, and theoretically suggested by the Bekenstein-Hawking formula relating the surface area of a black hole to its entropy content. (See: Jacob D. Bekenstein: "Information in the Holographic Universe". *Scientific American* August 2003 p. 58-65.) (See: "The Conversion of Space to Time"; see also: "The Half-Life of Proton Decay and the 'Heat Death' of the Cosmos".)

A Universe of Light

Consider the birth of a universe containing only light (free electromagnetic radiation) and no matter. Such a universe will expand (and cool) at velocity c due to the intrinsic spatial motion of light. Why?

The expansion of the "light universe" is not driven by energy conservation, for at any given moment the total energy of this light universe remains the same as it was at the beginning, the constant product of a declining temperature but increasing volume. That is, the light universe does not need to expand in order to conserve energy; energy conservation *regulates* the expansion but does not demand it. Apparently, the expansion of the light universe is likewise not driven by the conservation of energetic symmetry - since a "hot" light universe is just as symmetric as a "cool" light universe, so as in the case of the first law, symmetry conservation seems to be only a regulator, not a driver, of this process (this appearance is deceptive, however - see below). Finally, causality cannot drive the expansion, since light, having no time dimension, is completely a-causal. In the light universe, energy conservation will regulate the constant product of temperature and volume by linking the energetic and metric parameters of energy through the electromagnetic constant c (frequency multiplied by wavelength = c). Energetic symmetry conservation (Noether's Theorem), also gauged by c, will prevent the conversion of light and space to mass, time, charge, and gravitation. The spontaneous creation and annihilation of virtual particle-antiparticle pairs in the vacuum is paradigmatic of

symmetry conservation by the electromagnetic force, preserving the: 1) energetic (massless and chargeless); 2) metric (timeless and inertial); and 3) distributional (non-local and simultaneous) symmetry of free energy.

However, the second law of thermodynamics (entropy) demands the spatial expansion and is therefore the thermodynamic driver of the process, since the second law requires that the capacity for work of this isolated system of radiation must decline over time, requiring the light universe to cool, which it can only do by expanding. Therefore, we see that entropy is the thermodynamic reason why the light universe must expand, and why light must have an "intrinsic" (entropic) spatial motion. In addition, because "velocity c" gauges both the entropy drive and the symmetric energy state of light, we see that symmetry conservation provides half of the drive and rationale for light's intrinsic motion - free energy must move at velocity c if it is to remain in its "non-local" symmetric energy state, vanishing time, mass, charge, and gravitation. Energetic symmetry and entropy, in the case of light, are linked by "velocity c".

We can also see that the second law (and symmetry conservation) require a dimensional or metric structure (space) in which to operate (expand). Hence we can attribute the dimensional parameters of our cosmic system to symmetry conservation and the second law - the first law requires only that energy and its dimensional expression (if it is to have one) be linked in such a way that conservation is achieved - as the constant product of temperature and volume, for example, which of itself neither implies nor requires expansion.

The function of the second law is to permit change. Without the second law the universe could not spend or transform its energy capital - it could not act or evolve; it would be static rather than dynamic. Together, the first and second laws allow change within a dimensional system which nevertheless conserves energy. Symmetry conservation, which also regulates the metric parameters of the cosmic expansion, allows this system of conserved change to take a decisive further step - the conversion of light to matter - through the addition of a system of conserved charges, *the symmetry debts of light*. It is symmetry conservation that translates energy into information (the charges of atomic matter), while entropy allows the system to change and perform work. A third conservation parameter - raw energy conservation - regulates or "gauges" the conversion of free to bound energy: E = hν (Planck); E = mcc (Einstein); hν = mcc (deBroglie). With bound energy (mass, matter) comes gravitation, time, the law of cause and effect, and the causal information "matrix" (web, network) of matter (historic spacetime).

Through a system of alternative charge carriers (leptons, neutrinos, and mesons), and through the asymmetric interactions of the weak force "Intermediate Vector Bosons" ("IVBs"), the initial symmetric energy state of light, its metric, and its particle-antiparticle form is broken, creating asymmetric matter. (See: "The Higgs Boson and the Weak Force IVBs".) Finally, the gravitational charge of matter creates an alternative dimensional entropy carrier - time - an additional 4th dimensional parameter in which charge conservation and causal linkages can have extended significance, and in which the energy and entropy accounts of matter's relative (rather than absolute) spatial motions can be accommodated. Gravitation pays the entropy "interest" on bound energy's symmetry debt by producing matter's time dimension from the expansive energy or spatial entropy drive of the universe (by the annihilation of space and the extraction of a metrically equivalent temporal residue). Thus it is ultimately light's spatial entropy drive and expanding spatial domain

which provides the energy for matter's temporal entropy drive and expanding historical domain: gravity decelerates the spatial expansion accordingly. A new, complex universe of light mixed with matter, negentropic and causal, containing information in the primordial form of charge, begins its historic, evolutionary adventure as it slowly awakens to itself while returning the "stored" energy of its asymmetric material component to "working" and "useful" symmetric free energy. (See: "The Origin of Matter and Information".) During the long "working life" of the Universe, gravity repays the energy-"principle" of matter's symmetry debt, converting bound to free energy in stars, supernovas, quasars, and ultimately and completely, via Hawking's "quantum radiance" of black holes. Black hole "evaporation" represents the final fulfillment of Noether's symmetry conservation theorem. As the mass of the Cosmos is converted to light, its associated gravitational energy is accordingly reduced, and the cosmic expansion appears to "accelerate" - as recently observed.

Energy Conservation

The electromagnetic constant "c" gauges (regulates) both the entropy drive of light (light's intrinsic dimensional motion), and the "non-local" distributional symmetry of light, including the metric symmetry of spacetime. The metric is the measured relationship between the dimensions. We take for granted the fact that (stationary) meter sticks do not vary in length, nor (stationary) clocks vary in rate, regardless of their orientation or location in space or time (also assuming they co-exist in equivalent (or insignificant) gravitational fields). Clocks and meter sticks in Hong Kong run at the same rate and have the same length as clocks and meter sticks in New York, and could be freely exchanged (now or next year) without any measurable difference. Furthermore, the relationship between the length of a meter stick and the rate at which a clock runs is similarly invariant. This fixed, simple dimensional relationship is absolutely necessary for the conservation of energy; without it, velocity, momentum, and energy of all descriptions would vary chaotically from place to place, time to time, and according to orientation. Hence the stable metric displays a symmetry (a sameness) with respect to location and orientation in space or time, and this inertial symmetry is a manifestation of energy conservation - perhaps our most fundamental example of Noether's theorem and the connection between symmetry and energy conservation. We become aware of the breaking or distortion of this metric symmetry in the presence of gravitational fields or the inertial ("g") forces due to acceleration - but these are both phenomena associated with time, relative motion, and the asymmetric realm of matter. Similarly, distortions of the metric due to relative motion (as discovered by Einstein) are phenomena of matter, necessary to conserve the causal relations of bound energy forms in relative (rather than absolute) motion ("Lorentz Invariance" - the co-variance of space with time).

In the light universe, time, gravitation, charge, relative motion, and the inertial forces which attend mass-matter do not exist. What inertial force does exist can be said to maintain the invariance of c, the metric symmetry of space, and the non-local distributional symmetry of light. Without a metric, there would be no structure to regulate the expansion of the universe such that its temperature and volume yield a constant product over time, in satisfaction of the first law (energy conservation). "Velocity c" regulates ("gauges") the metric such that one second of temporal duration is metrically equivalent to (approximately) 300,000 kilometers of linear space. In other words, the velocity of light is a natural expression of metric symmetry, the inertial relationship between the three spatial dimensions, and between space and time. The magnitude of c cannot vary or the first law cannot produce the constant product of volume and temperature in the expanding universe. Without the regulating presence of the metric, every photon might have a unique velocity; "rogue" or sourceless gravitational fields could

arise, producing net energy; time and length scales would be incoherent: energy conservation would be impossible. This is the world of "Alice in Wonderland" where anything is possible but nothing makes sense.

Einstein discovered that light has no time dimension, that at velocity c the "clock stops" and space shrinks to nothing in the direction of motion. Light is a 2-dimensional transverse electromagnetic wave whose intrinsic motion sweeps out a third spatial dimension. Light requires one dimension each for its electric and magnetic fields, and a third in the direction of propagation for its entropic expansion - space. The light universe does not contain an explicit (local) time dimension, it is purely spatial, which makes sense in that being one-way, time is an asymmetric dimension which would destroy the metric symmetry of light-space. The essential meaning of the universal electromagnetic constant "c" is that c is the conservation/symmetry/entropy gauge of the spatial metric, which functions to prevent the formation of asymmetric massive matter, charge, and the one-way time dimension. The dimensional and energetic parameters of this electromagnetic conservation domain are thoroughly linked such that the wavelength of light (its spatial expression) multiplied by the frequency of light (its temporal expression) always equals the constant "c". Nevertheless, even in the light universe, a "global" temporal dimension must be at least implicitly present to regulate the expansion and cooling. Entropy (and energy conservation) require the presence of time, whether implicitly or explicitly expressed. (See: "The Conversion of Space to Time".)

Obviously, time is implicit in the "frequency" of light, but at "velocity c", time is prevented from becoming explicit (conserving metric symmetry). The seed is present, but its growth is suppressed; indeed, time would be required in its explicit and local aspect should light assume its asymmetric particle form and produce matter. In fact, we need to discover the origin of the time dimension in light if we are to build a truly unified theory of free plus bound electromagnetic energy and its compound dimensional conservation domain (historic spacetime), a theory which traces the origin of all forces back to light. "Frequency" is this origin in the case of time, as well as the origin of the bound energy content of matter - in the latter case when combined with the dimensional/structural metric of space (as suggested by DeBroglie's equation: $h\nu = mcc$). In turn (as we shall see below), time is the source of gravity. (See also: "The Higgs Boson vs the Spacetime Metric".)

In the case of matter, local time is explicitly required by energy conservation to protect causality and to keep the energy accounts of massive particles in relative motion (for example, the conservation of momentum, in which the energy content of matter depends upon its variable and relative velocity, where velocity = distance divided by time). Light does not explicitly require time for the same purpose, since light's absolute (non-relative) velocity never varies: the energy content of light varies instead with its frequency (according to the Einstein-Planck formula: $E = h\nu$). Finally, because massless light is "a-temporal" and "non-local", light is also "a-causal". Massive bound energy, in contrast, is local, temporal, and causal. Einstein had to formulate the dimensional flexibility of Special Relativity (slow clocks and shrinking meter sticks - the covariance of space with time - "Lorentz Invariance") to rescue the principle of causality and the invariance of the "Interval" (an invariant measure of distance in 4-D spacetime) from the relative motion of matter. The "absolute" and invariant motion of light requires no such accommodation (light's "Interval" = zero).

It is the ever-present threat of time, implicit in the very nature of light as "frequency", which propels the electromagnetic wave forward in space to protect its "non-local" distributional and metric

symmetry. The flight of space ("wavelength") from time ("frequency") produces the intrinsic (self-motivated) motion of light, a symmetric spatial state of energy fleeing an asymmetric temporal state which is an internal potential of its own nature (the proverbial "bur under the saddle"). Since the intrinsic motion of light (the "drive" of spatial entropy) also produces the characteristic expansion and cooling of space, we see again that energy conservation, symmetry, and entropy are all related and share a common factor, "c". Hence we say that both metric symmetry conservation and entropy, in the service of energy conservation, are drivers of the spatial expansion of the light universe, just as we say that (among other roles) "velocity c" is the gauge of light's entropy drive and of light's "non-local" distributional symmetry. Time is both the *implicit* spatial entropy drive of light and the *explicit* historical entropy drive of matter.

Our material universe comes into being through the intersection of a symmetric conservation domain (light, space) with an asymmetric conservation domain (matter, history). The metric gauge c is a symmetry regulator preventing the intersection of space and time, and thus preventing free electromagnetic energy (light) from spontaneously manifesting as bound electromagnetic energy (matter). (See: "The Origin of Matter and Information".) When these two domains do intersect (one is derived from the other), their interaction is gauged by Newton's gravitational constant "-G".

Symmetry and the "Interval"

The "Interval" is Einstein's mathematical formulation of an invariant quantity of spacetime separating two discrete events. Due to their relative motion and the finite speed of light, some observers of these events will see them separated by more space, while others will see them separated by more time, and moving observers will generally not be able to agree on precisely when the events occurred, or if they were simultaneous. However, regardless of the observer's motions (including accelerated motions), if their observations are entered into Einstein's mathematical formula, they will all find the same "Interval" ("Lorentz Invariance"). It is the crucial function of Einstein's "Interval" to rescue causality from the plastic, co-varying dimensions of Einstein's relativistic spacetime [3]. (See: "The Paradox of the Traveling Twins".)

Einstein realized that the Interval of light equals zero - which is his essential mathematical formulation of light's "non-local" symmetric energy state and the fundamental role of "c" as a symmetry "gauge" and metric regulator. Light's "zero Interval" means that light is "non-local" - its position in spacetime cannot be specified - hence (in its own reference frame) light must be considered to be everywhere within its conservation domain (space) simultaneously. The reason the Interval of light is zero is that light lacks both a time dimension and one spatial dimension (in the direction of its forward motion). You cannot specify a location in 4-dimensional spacetime if you lack even one of the 4 necessary coordinates, much less two. Lacking both a time and distance dimension, light has forever to go nowhere - which explains how light, in its own reference frame, can have an effectively "infinite" velocity, and be everywhere simultaneously - the symmetric "non-local" state of free energy.

Of various symmetries associated with light's zero Interval or "non-local" energy state, two are of special importance for our discussion of gravitation. The first is light's lack of an asymmetric time dimension, resulting in the metric symmetry of space - there are no energetically preferred spatial dimensions in light-space (compare this with the energetically favored direction "down" in the

gravitational space of matter, or the one-way "forward" direction of time). Secondly, because light is everywhere within its spatial domain simultaneously, light's energy is distributed symmetrically throughout its conservation domain (compare this with the lack of distributional symmetry in space of the highly concentrated and immobile "local" energy state of atomic mass-matter or bound energy). Light itself does not produce a gravitational field - since light is non-local, a gravitational field could not center itself upon any fixed position or specifiable location, and an uncentered gravitational field is a violation of energy conservation (because such a field would produce net energy). Furthermore, light has no time dimension, and hence has no need for a gravitational field to produce one. (See: "Does Light Produce a Gravitational Field?")

When light (free electromagnetic energy) is converted to matter (bound electromagnetic energy), these metric and distributional symmetries (among others) are broken. In accordance with Noether's theorem, the broken symmetries of light are conserved as time and the gravitational forces of spacetime (in the case of light's broken entropic, metric, and non-local distributional symmetries), and as the various charges (and spin) of matter (in the case of light's broken massless symmetry, producing massive particles). The principle of symmetry conservation is therefore most familiar to us (after symmetry-breaking and the creation of matter) through the principles of charge conservation, gravitation, the inertial "g" forces of acceleration, and time; before symmetry-breaking and before the creation of matter, we see (in theory) symmetry-conserving principles manifesting in light's intrinsic motion, metric symmetry, the inertial forces of space, and the suppression (by the symmetry gauge "velocity c") of virtual particles, mass, charge, time, and gravity. It is the broken "non-local" metric and distributional symmetries of light that give rise to the "location" charge of gravitation, a charge whose active principle is time. The function of all conserved charges is to produce forces which will (immediately or eventually) return the material asymmetric system to its original symmetric state (light). Stars and quasars are prime examples of this ongoing process - both use the natural forces generated by the charges of matter (which include gravity) to convert asymmetric mass back to symmetric light. Stephen Hawking's "quantum radiance" takes this spontaneous, gravitationally driven process to completion in "black holes", completely paying the symmetry and entropy debt of matter. (See: "Symmetry Principles of the Unified Field Theory".)

The role of symmetry conservation is twofold: 1) to prevent the devolution of the a-causal symmetric light universe to a causal light-and-matter universe containing asymmetric mass, charge, time, and gravitation (this preventive function of symmetry conservation is typically manifest through the role of electric charge in the annihilation reactions of matter-antimatter particle pairs, whether virtual or real). 2) To conserve through time (should the annihilation reactions mentioned above fail) the symmetry debts of light and space as the charges (and spin) of matter (including the gravitational "location" charge), so this information may be used, through the forces generated by those charges, to return matter to its original symmetric energy state (light). It is thought that the symmetric state of our electromagnetic system was broken early in the "Big Bang" by asymmetries inherent in weak force interactions between matter vs antimatter [4]. (See: "The Origin of Matter and Information".)

The central problem to be solved by the manifest universe of matter is this: how to return to its original symmetric energy state of light given the absence of antimatter? The information contained in the charges of matter (the symmetry debts of light) is sufficient for the task (this is the ultimate rationale for information), but requires an additional 4th, alternative, entropy-carrying dimension - time - in which to act. Time will be supplied by gravity paying the entropy-"interest" on matter's

symmetry debt with energy withdrawn from the spatial expansion of the Cosmos. The slow return to its symmetric state of the great energy stored in matter (E = mcc) provides both the time and free energy for biological systems such as ourselves to evolve and meditate upon our origins - "we are star-stuff contemplating the stars" as Carl Sagan famously observed. Life is the information pathway by which the Universe becomes self-aware and explores itself, evolving new modes of creativity, new information pathways, and new forms of beauty. We are "the eyes and the ears" of the Universe; we are the Universe in its conscious, sentient, and self-referent mode; and we are very much created in the "image and likeness of" a <u>fractal iteration of its information content.</u>

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See: Science vol. 337 3 Aug., 2012 pp. 536 - 547: special section on black holes.

Links:

Unified Field Theory

Gravitation

Entropy

End of Part I - Go to Part II