Spatial vs Temporal Entropy: Part I

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Abstract

The subject of entropy can be dauntingly technical in its full thermodynamic formality. However, we are primarily interested in three simple, fundamental, and typically overlooked examples of entropy in its most common, primordial, and significant form: 1) the dimensional spatial expression of entropy as observed in the cosmological expansion and cooling of space; 2) the dimensional temporal expression of entropy as observed in the cosmological expansion, decay, and causal dilution of history; 3) the continuous formation of spacetime by the negentropic action of gravitation. These dimensional or entropic conservation domains are created by the primordial entropy drives of free electromagnetic energy (light's intrinsic motion), and bound electromagnetic energy (mass/matter - the historical entropy drive of time's intrinsic motion).

Gravity is the spatial consequence of the intrinsic motion of time. Gravity is the neg-entropic face of matter's pos-entropic historical entropy drive. Gravity creates time by the annihilation of space and the extraction of a metrically equivalent temporal residue, creating spacetime, the compound entropic domain of free and bound forms of electromagnetic energy. Time, in turn, creates gravity as it rushes into history, pulling space after it. Time is the active principle of gravity's "location" charge. (See: "Entropy, Gravity, and Thermodynamics".) Time and gravity induce each other, analogously to an

electric and magnetic field, but of course via a very different mechanism (see: "The Conversion of Space to Time"). Spacetime is a rather complex entropic domain - space and history are linked by negentropic gravity which converts either into the other. (See: "The Double Conservation Role of Gravitation".) The expansion of history is at the expense of the expansion of space; the rate of expansion of historic spacetime is reduced compared to the rate of expansion of pure space. Gravity is the "go-between", conversion force, or "gauge" of equity/proportionality between the spatial and historical entropy drives of free and bound electromagnetic energy. (See: "A Description of Gravitation".)

Introduction

Unless the context indicates otherwise, when I refer to "entropy" in these papers (especially in such phrases as "light and the drive of spatial entropy" or "matter 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" (in the case of "spatial entropy"), or as the intrinsic motion of time, "velocity T" (in the case of historical or "temporal entropy"). These two entropy functions are inextricably linked through the spacetime metric (also gauged by the electromagnetic constant "c"): one second of temporal duration is metrically equivalent to 300,000 kilometers of linear space; and through Einstein's "Interval"; and through the formulation "frequency multiplied by wavelength = c". Finally, they are also linked through the gravitational conversion of space to time, and the converse, the transformation of bound to free energy (as in the stars). (See: "The Tetrahedron Model".)

Part I: Pure and Mixed Forms of Entropy

Entropy exists in several related forms in nature, all with the same purpose, to prevent violations of energy conservation. In these papers, I distinguish between:

1) Primary or spatial entropy, the entropy of expanding and cooling space, the entropy of free electromagnetic energy, radiation, or light, whose "drive" or essential motivating dynamic is the intrinsic motion of light, as "gauged" or regulated by the electromagnetic constant, "velocity c". (We are accustomed to think of space as static and time as dynamic, because of our own inertial stasis and the effects of scale, but space is just as dynamic as time in the entropic sense, constantly expanding and cooling due to its energy content and its entropy drive, the intrinsic motion of light. The expansion is actually visible through our great telescopes as the "red shift" of distant galaxies).

2) Secondary or temporal/historical entropy, the entropy of expanding and aging history, the entropy of bound electromagnetic energy, mass, or matter, whose "drive" is the intrinsic motion of time ("velocity T"), also "gauged" or regulated by velocity c. Time is defined as the duration (measured by a clock) required for light to travel a given distance (measured by a meter stick) in vacuum. As Einstein has demonstrated, space and time are not independent variables, nor are their primordial entropic drives. Space is ultimately related to the wavelength of light, and time to the frequency of light, such that frequency multiplied by wavelength = "velocity c" (an invariant, the universal electromagnetic constant).

One can circumvent any circularity in measuring space by time by resorting to the independent variable "number", and (choosing a convenient "gauge" or standard frequency), count a fixed number of oscillations of light to measure a standard duration. A standard distance is then given by the space

traversed by these same oscillations - since "c" is invariant. Time is derived from space by the gravitational annihilation of space, and/or the quantum mechanical collapse of an electromagnetic wave. (See: "The Conversion of Space to Time".)

3) Gravitational entropy, a negative form of entropy, converting and hence conserving one primordial entropy form to the other in either direction (space to time or vice versa): driven by the intrinsic motion of matter's gravitational field, as gauged by the universal gravitational constant "G". Gravitation is the conversion force between the primordial drives of spatial and temporal entropy. Matter's gravitational field is in turn *the spatial consequence of the intrinsic motion of matter's time dimension:* time and gravity induce each other much as electric and magnetic fields induce each other. Gravity is therefore related to c through time and entropy; hence all intrinsic (dimensional and entropic) motions are ultimately derived from or related to "c". Whereas "c" is the gauge of the *metric* relation between space, time, and free energy (light), "G" is the gauge of the *entropic* relation between space, time, and bound energy (mass).

Time or temporal entropy can be regarded as a "local" form of entropy drive, derived from the "global" entropy drive of light (by the gravitational annihilation of space and the extraction of a temporal residue). Spacetime is a "tale of two metrics": the action of gravitation converts a global metric of space, light, and absolute motion gauged by "c", to a local metric of time, history, matter, and relative motion gauged by a combination of "c" and "G". Time is the local compensating component of the gravitational field vector (spacetime) - the local gauge symmetry "current" - protecting the invariance of the "Interval", causality, and "velocity c" ("Lorentz Invariance" of Special and General Relativity). Because time and space are co-varying parameters, energy conservation is accomplished despite the variable and relative motions of matter, and despite variations in the strength of the local gravitational field. In this regard, time is the functional analog of the magnetic component of the electromagnetic field (which protects the invariance of electric charge in relative motion). We may also think of time as an alternative entropy-carrying dimension for space, necessary for the transformation of light to matter, analogously to the role of the leptons and mesons in the material realm, which function as alternative charge-carrying particles for baryons. (See: "Global vs Local Gauge Symmetry and Gravitation".)

4) Spatio-temporal entropy, a tertiary form of combined entropy ("ordinary" or "textbook" entropy), resulting from the mixture of the primary, secondary, and gravitational forms (generally producing matter in relative motion), conceived and formulated in two distinct treatments:

> a) The familiar thermal entropy (S) of "work", due to Carnot (1824) and Clausius (1850), manifesting as "heat" (Q) divided by absolute temperature (T): dS = dQ/T (the entropy associated with molecular motion and kinetic energy);
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> b) The statistical or probabilistic interpretation of entropy due to Boltzmann (S = K ln W), where K = Boltzmann's constant (an energy measure per degree of absolute temperature), and ln W is the natural logarithm (ln) of a probability expression (W). In Boltzmann's conception (1870s), entropy manifests as the most probable, most symmetric, or most random molecular state (the entropy of probability with respect to the distribution of molecules and their kinetic energy, temperature, or state of excitation). Claude Shannon's communication entropy (1948) follows the formalism of Boltzmann's

model.

> The equivalence between the thermal and the probabilistic formulations of "standard" entropy is complete and can be expressed by the equation: dQ/T = K ln W. In other words, probability (at least at the molecular level) is a force in nature which can be expressed in the energetic terms of heat or calories, and therefore "work" and entropy.

Gravity converts space and the primordial drive of spatial entropy (the intrinsic motion of light) to time and the primordial drive of historical entropy (the intrinsic motion of time). When free energy is converted to bound energy, a portion of 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. (See: "A Spacetime Map of the Universe".)

The gravitational conversion of space to time is physically demonstrated by black holes, and mathematically suggested not only by Einstein's gravitational equations representing the distortion of spacetime, but also by the Bekenstein-Hawking theory relating the surface area of a black hole to its entropy content. The "surface" of a black hole is a time surface, a boundary of pure temporal entropy, where space is completely converted to time by gravity. (See: "The Half-Life of Proton Decay and the 'Heat Death' of the Cosmos".)

Thermal or "Work" Entropy

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 or randomization of energy inherent in the operation of any engine or process of energy transformation, typically manifesting 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. As Carnot pointed out, if all the energy of a system could be transformed to work, then the cycle could be reversed through mechanical linkage to a duplicate system, converting all the work back to energy, thus realizing the possibility of a perpetual motion machine - a violation of energy conservation. We therefore come to the realization that entropy is a principle safeguarding energy conservation. Entropy prevents the abuse of energy while allowing its use and transformation; without the principle of entropy, energy conservation would prevent any use of energy at all.

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

It is because of their conservation functions as entropy "drives" that both the intrinsic motions of light and time have the appearance of "infinite" velocities. These "infinite" velocities are necessary

attributes of these entropy drives, protecting their respective conservation domains (space, history) from violations of energy conservation or causality (via super-luminal space ship or time machine), ensuring the irretrievable loss of radiant energy and the "present moment" to an expanding universe of space and/or history. Gravity also seals the borders of spacetime via the "event horizon" and central "singularity" of black holes, preventing conservation breaches (in either direction) via "wormholes". Hence the entropy drives which create the dimensional conservation domains of spacetime also close the borders of their domains to protect them against conservation violations - as we should expect. Black holes, in fact, illustrate the case in which the primordial entropy drives of intrinsic motion c and T do not exist, both extinguished and replaced by a wholly gravitational metric. Change cannot occur within the black hole except by gravitational action, including (possibly) the conversion of baryons to light via "proton decay" at the central singularity; and the direct conversion of gravitational energy to radiant energy at the event horizon, producing "Hawking Radiation".

Fundamentally, entropy is and must be an intrinsic, inherent attribute characterizing free or bound energy. Ordinary, "textbook" or "spatio-temporal" entropy is a mixture of the two primordial forms: molecules in relative motion in time and space. (See: "The Tetrahedron Model.")

In general, the capacity for work of any (isolated) system must decrease over time, although the rate at which this incapacitation occurs depends heavily upon the state of the energy in the system, especially whether the energy is free or bound. So long as energy remains in the form of free energy (light), its entropy drive, velocity c, naturally causes a very rapid vitiation of its potential for work. It is therefore of cardinal importance (from the point of view of the "Anthropic Principle") that at the beginning of the Universe some free energy is converted (via an unknown mechanism involving weak force symmetry-breaking) to the bound form of matter. In thermodynamic terms, we can think of the creation of matter as the "work done" at the beginning of the Universe: never again would the Universe attain a sufficient temperature and energy density to create matter. The creation of matter from light qualifies as "work" in that it is an "uphill" process, since light is a symmetric energy form, and matter is a derivative, asymmetric energy form. We can think of gravitation as both an entropy and a symmetry debt consequent upon this conversion of light to matter (see: "The Double Conservation Role of Gravitation"). The magnitude of G reflects the small energy difference between the symmetric entropy drive (S) of free energy (the intrinsic motion of light, gauged by "velocity c") and the asymmetric entropy drive (T) of bound energy (the intrinsic motion of matter's time dimension, "velocity T"):

$$S - T = -G$$

This is equivalent to the small energetic difference between implicit (S) and explicit (T) time (see: "The Conversion of Space to Time", and "Gravity Diagram No. 2").

The deceleration of the cosmic spatial expansion reflects the gravitational conversion of space and light's symmetric spatial entropy drive to time and matter's asymmetric historical entropy drive - the gravitational conversion of the spatial expansion of the Cosmos to the historical expansion of the Cosmos (the gravitational creation of historic spacetime). The Cosmic spatial deceleration therefore debits the expansive entropy-energy of light to fund the historical dimension of matter. This deceleration is moderated as gravity reconverts matter to light (as in the stars), because light produces no gravitational field in free flight. The gravitational conversion of space and the drive of spatial

entropy (light's intrinsic motion: S) to time and the drive of historic entropy (time's intrinsic motion: T) can be represented symbolically by a "concept equation" as:

$$-Gm(S) = (T)m$$
$$-Gm(S) - (T)m = 0$$

I enclose (S) and (T) in parentheses to indicate they are something more than simple quantities: they represent the primordial entropy drives or intrinsic motions of light and time. Of course I imply that the equivalent of these simple-minded "concept equations" must in some fashion occur in the quantitative formalism of Einstein's gravitational field equations; it is the transformation of space into time that creates his famous "warped" or "curved" spacetime.

The gravitational symmetry debt of the Universe is due to the reduced distributional symmetry of "local" bound energy (matter) as compared to "non-local" free energy (light). This debt is paid generally (along with all others) by the gravitational conversion of matter back to light, as in stars, quasars, and by Hawking's "quantum radiance" of black holes. *The charges of matter are the symmetry debts of light* (Noether's Theorem) - including the gravitational "location" charge, whose active principle is time. (See: "Symmetry Principles of the Unified Field Theory".)

Primordial Entropy Drives of Light, Time, and Gravity

The primordial entropy drive of bound energy (matter) is the intrinsic motion of time, "velocity T". Unlike light and light's entropic dimensional conservation domain (space), matter does not fill its entropic dimensional conservation domain (historic spacetime), nor expand as the Cosmos ages; it is not matter that moves, but matter's time dimension. (See: "The Time Train".) Matter exists always on the tangential cusp of historic spacetime in the "Universal Present Moment" (see: "A Spacetime Map of the Universe"). The energy potential of atoms can therefore last without attenuation for many thousands of eons - the half-life of proton decay is so great it still has not been measured.

The intrinsic motion of the time dimension is the primordial entropy drive of material systems, replacing the intrinsic motion of light from which it is derived (by the gravitational or quantum-mechanical annihilation of space and the extraction of a metrically equivalent temporal residue, converting implicit to explicit time). Among time's other functions (such as the establishment of causality, protection of the "Interval" and historical connectivity, and the accommodation and continuous updating of the energy accounts of matter in relative motion), time safeguards symmetry conservation via charge conservation. Time provides the dimensional arena (history) in which charge conservation has extended meaning and can fulfill its deferred conservation function at some future but indefinite date. (See: The Conversion of Space to Time".) This is yet another connection between entropy and symmetry. (See: "The Tetrahedron Model".)

The weakness of gravity is due both to the small energy difference between implicit and explicit time, as noted above, and to the tangential connection between matter and its historical conservation domain (historic spacetime) - experienced by us as the transient "present moment". This tangential connection reflects the fact that it is matter's time dimension that has intrinsic, entropic motion, and not matter itself. The separation between matter and its historical conservation domain (in contrast to the intimate relationship between light and space) is the root cause of human anxiety regarding our fleeting experience of life, but is necessary to protect the energy of atoms from the vitiating action of

temporal entropy (aging). In consequence of this protection, atoms retain the full value of their energy content and charge magnitudes until their energy and symmetry debts are paid in full - either gravitationally by Hawking's "quantum radiance" of black holes, or electromagnetically by matter-antimatter annihilation, or by the strong and weak nuclear forces through "proton decay".

Bound energy is simply stored in the "eternal present moment" of the time dimension, without spatial attenuation, under guarantee of charge conservation, which promises to release the energy upon contact with the appropriate anticharge (antimatter). Gravity pays the storage fee or entropy-interest on this symmetry debt by creating the time dimension from the entropy-energy of free energy and space, decelerating the expansion of the Cosmos in consequence. On the local scale, "work" and its associated spatio-temporal entropy in the Universe today is typically achieved by releasing energy from a "cold" stored temporal mode to a "hot" free spatial mode (as in the burning of chemical or nuclear fuels).

Hence by shifting from a primary "hot" free energy conservation system of spatial entropy involving immediate raw energy conservation through spatial expansion and cooling at "velocity c", to a secondary, alternative "cold" bound energy conservation system of temporal entropy, involving time-deferred charge conservation and a moving time dimension to which matter is only tangentially connected, the Universe finds a method of storing and releasing its energy slowly, allowing itself time to do the work of evolving life, consciousness, intelligence, and self-awareness.

Part II: Spatial, Historical, and Spatio-Temporal Mixed Entropy

Readers will naturally wish to know if the views of entropy put forward in these papers are compatible with the standard version of the subject. It is my firm belief that they are; the expanding (and cooling) spatial universe and the expanding (and aging) historical universe are both perfectly "legitimate" expressions of entropy on the macroscopic scale. The negative entropic character of gravitation is likewise well known. I am simply focusing on the underlying ("primordial") origins of the entropy drive as found in the "intrinsic motions" of light, time, and gravity (the primordial entropy drives of free energy, bound energy, and the gravitational conversion force acting between them), while the "textbooks" typically emphasize "spatio-temporal" or "work" entropy, that is, the mixture of the three forms which characterize the very complex world of our daily material experience.

Ordinary "textbook" entropy ("spatio-temporal", thermodynamic, or "work" entropy) is a mixture of the spatial entropy drive of free energy (the intrinsic motion of light, as gauged by "velocity c"), and the historical entropy drive of bound energy (the intrinsic motion of time, "velocity T") - matter set in motion by free energy: free energy captured by matter and the mixture expressed through the momentum, kinetic energy, temperature, causal history, and the relative motion of atoms and macroscopic masses. Hence different rules apply to the entropy relations of matter-in-motion than to free light, namely the typical thermodynamic rules of ordinary material systems ("heat", equilibrium, probability, random distributions, etc.). However, the underlying entropic drives remain the same - the effectively "infinite" velocities of light and time, which insure the one-way increase in entropy, manifest as the expansion, cooling, aging and decay of the spatial and historical Cosmos. Negentropic physical processes typically involve gravity: *gravity is the spatial consequence of the intrinsic motion of time*. Entropy continues to increase despite the negative spatial entropy drive of gravitation; gravity simply converts the primordial form of entropy drive from its spatial free energy expression (the

intrinsic motion of light) to its historical bound energy expression (the intrinsic motion of time) and vice versa - the latter in stars, quasars, and via Hawking's "quantum radiance" of black holes. (See: "Entropy, Gravitation, and Thermodynamics".)

Every and any process that converts free to bound energy produces a corresponding increment in the gravitational field associated with its material system, and a proportional *deceleration* of cosmic spatial expansion due to the actual loss (by gravitational annihilation) of space and the concomitant conversion of the spatial entropy drive to time. Conversely, every and any process that converts bound to free energy produces a corresponding reduction in the gravitational field associated with its material system, and a proportional *acceleration* of cosmic spatial expansion. Hence there are no processes and systems, whether "pure" light or compounded light and matter, that operate independently of the primordial entropic drives and domains of c, G, and T. (See: "The Conversion of Space to Time".)

Time's Arrow

Irreversibility ("time's arrow") - is due to the "local" character of matter (as compared to the "non-local" character of light). Matter needs a time dimension to establish causality and maintain causal linkages (for reasons of energy conservation), as well as to provide its entropy drive and balance its energy accounts. Matter's variable velocity in spacetime means its energy content (momentum, kinetic energy) also varies as a function of velocity (distance/time), and relative to the motions of other masses. Light does not need time for the same reasons, because light's intrinsic motion provides its own entropy drive: light's motion is invariant and absolute rather than variable and relative. Finally, light is "non-local", hence does not need causal linkages. Because light is everywhere simultaneously, and has no time dimension, causality is irrelevant in light's own reference frame. Light is non-local, atemporal, and acausal; matter is local, temporal, and causal. Causality and the increase of historical entropy (aging) in the service of energy conservation are the sources of temporal irreversibility in material (massive) systems of every scale, and both are rationales for gravitation. The one-way character of time's intrinsic motion is also the cause of gravity's one-way spatial collapse: *gravity is the spatial consequence of the intrinsic motion of time*.

Information

Does the combined form of spatio-temporal entropy produce physical dimensions as does the intrinsic motion of the "primordial" pure forms? Historical spacetime is the product of the intrinsic motions of light, gravity, and time, not the direct product of spatio-temporal entropy. However, spatio-temporal entropy produces (with the necessary help of gravity and evolution) the negentropic information domain of biology, which can readily be argued is a dimension in its own right, especially at the level of the abstract information systems of advanced human societies (the arts, sciences, technology, culture), or indeed, of human thought itself (imagination). If we grant that information (including life) is a type of dimension, then spatio-temporal entropy indeed produces a dimension, as do the other three entropy forms (space, history, historical spacetime). Shannon's communication entropy (1948) would appear to be a related mixed form of spatio-temporal entropy unique to the information dimension. The information dimension is physically related to historic spacetime; both are required by the causal nature of matter. Historic spacetime is the conservation domain of information and matter's "causal matrix" (the source of consequential repercussions or "karma"). Nuclear, chemical, and biological evolution and the forward march of "progress" and complexity may be the evidence of a

one-way entropic drive in the information domain, perhaps involving a 4x3 fractal algorithm. (See: The Information Pathway".)

The 3rd Law of Thermodynamics

The third law of thermodynamics (due to Nernst, 1905) states that the entropy of every system is zero at absolute temperature zero (Kelvin scale). This makes sense in that if a system contains no energy then it also contains no entropy. However, Einstein tells us that even the coldest atom contains rest-mass energy, and hence there should be some form of entropy to accommodate this "bare" rest-mass energy. This of course is the primordial temporal and gravitational entropy we have discussed above, so the third law is not applicable to primordial entropy drives and systems, but only to mixed systems of spatio-temporal entropy (atoms in relative motion).

We can visualize a material system (atoms) which at absolute zero has only temporal entropy (gravity and the passage of time), patiently awaiting an interaction with light (free energy). As soon as the temperature is raised above absolute zero by the entrance into the material system of free energy, the atoms/masses begin to move, free energy becomes bound as momentum and kinetic energy, and we enter the complex realm of compounded spatio-temporal entropy ($dS = dQ/T$) with its parameters of heat, work, equilibrium states, probability distributions, etc. However, even at absolute zero, matter retains its full temporal entropy - time and gravity flow regardless of temperature, and likewise radioactivity and proton decay, also expressions of temporal aging or entropic decay in stationary matter, are unaffected by low temperatures. Causality and velocity c also have no dependence on temperature: we see that the primordial entropic drives of time and space are quite unaffected by the third law.

The entropy formula above ($dS = dQ/T$) says that the variation in entropy (dS) of a material system (for example, a liter of water), varies with its "heat" or thermal energy content (dQ) divided by its absolute temperature (T) (Kelvin scale). The formula thus provides a measure of the concentration and intensity of thermal energy in a system, the system's "potency", its "capacity for work". Note however that the formula addresses only the internal entropy of one part of a much larger system, ignoring the source of heat, interactions with the environment, gravity, the temporal evolution of the system, radioactivity, the rest mass energy contained in the atoms themselves ($E = mcc$), etc. To present a really complete picture, the formula would have to be set within its entire cosmic context, including the background temperature of spacetime, the age of the Universe, whether the Cosmos is expanding or contracting, a gravitational environment, the radioactive context, etc.

The net contribution of the primordial drive of spatial or light entropy to spatio-temporal entropy is irreversible heat loss, radiation, thermal energy and the motion of massive atoms, molecules, and macroscopic objects (kinetic energy, momentum), excited energy states, the temperature-dependent thermodynamic entropy representations of Carnot and Clausius. The net contribution of the primordial drive of pure temporal or material entropy to spatio-temporal entropy is the irreversible loss of opportunity and the fleeting "present moment", causality, probability, including the half-life of radioactive forms and proton decay, and the time-dependent entropy representations of Boltzmann and Shannon. Because gravity is the spatial consequence of the intrinsic motion of time, gravity is a spatial form of time, a precursor to and motivator for historical entropy. The negative entropy drive of gravitation transforms space to time, the temporal entropy drive of history.

In biology, the temporal connection becomes negentropic through evolution (natural selection operating on genetic variation). Gravitation is the connection (conversion force) between the primordial drives of spatial and historical entropy - (intrinsic motions c, G, T) - becoming the dominant expression of negative spatial entropy in the macroscopic phenomena of spacetime, the combined dimensional conservation/entropy domain of free and bound electromagnetic energy, as welded together by gravity. (See: "The Tetrahedron Model"; see also: "Darwin, Newton, and the Evolution and Abundance of Life in the Universe".)

The Conservation of Entropy and Symmetry

Entropy is not conserved in the same sense as energy; total energy is a constant, but total entropy always increases. For example, the spatial and/or historical universe constantly expands. Entropy is conserved in the sense that it never decreases in an isolated system; primordial forms of entropy are converted from spatial to metrically equivalent temporal expressions (and vice versa) by both gravity and quantum mechanical mechanisms. Entropy is a quality or characteristic of energy, and is itself a form of energy, as we see most directly in gravitation or its inverse, the expansion of the Cosmos. What is conserved in entropy's primordial forms is the intrinsic motions, c or T; one is converted into the other by gravitation (or by quantum mechanics, as during the absorption and emission of a photon by the electron shell of an atom - see: "The Conversion of Space to Time".) In other words, the role of entropy itself is continuous, whether manifest as the intrinsic motion of light (the entropy drive of free energy, creating space) or the intrinsic motion of time (the entropy drive of bound energy, creating history). Neither c nor T has any dependence upon the quantity of energy it is associated with, nor has G, the universal gravitational constant, the gauge of the gravitational force converting c into T and vice versa. The magnitude of G measures the small energy difference between the symmetric entropy drive of free energy (S) (the intrinsic motion of light, as gauged by "velocity c") and the asymmetric entropy drive of bound energy (T) (the intrinsic motion of matter's time dimension, "velocity T"):

$$S - T = -G.$$

Entropy is conserved not only because it is an embedded characteristic of energy, but also because of its close association with the symmetry of energy, which is strictly conserved in accordance with "Noether's Theorem": the electromagnetic constant "c" gauges the "non-local" distributional symmetry of light (vanishing time and distance), the entropy drive of light (light's intrinsic motion), and the inertial (dimensional) symmetry of the spatial metric.

"Noether's Theorem" requires that the symmetry of free energy (light) be conserved: *the charges of matter are the symmetry debts of light*. Light's metric symmetry is expressed through light's "non-local" character and intrinsic motion, as gauged by c, and is actively protected by the inertial and gravitational forces of spacetime (including "Lorentz Invariance" of Special and General Relativity - the covariance of space and time). It is essentially this non-local symmetric energy state of light that the gravitational "location" charge conserves. Light has no time dimension, nor spatial extension in the direction of its propagation; light is a 2-dimensional transverse wave, and in consequence of its lack of both a spatial and a temporal dimension, light is everywhere simultaneously within its spatial domain. This "non-local" attribute is necessary to accommodate the entropic role of the electromagnetic constant "c" and its function as the gauge of spacetime's metric symmetry, which must operate regardless of the size or expansion rate of the Cosmos. Hence both roles require, for

their effective functioning, light's "infinite" velocity.

Gravitation is the symmetry and entropy-conserving force responding to the breaking of massless light's non-local spatial symmetry when light is converted to immobile, massive matter, acquiring a specifiable location in spacetime. Matter's spacetime position (including the magnitude and intensity of the distributional symmetry violation represented by immobile matter's undistributed "local" energy concentration) - is forcefully identified by gravitation, which moreover creates matter's time dimension by the consumption and conversion of space to its metric equivalent, time. (The gravitational charge is "location" and time is its active principle - combining in one charge the entropy and distributional symmetry debts of immobile, "local" matter. Time and gravitation induce each other endlessly. See: "A Description of Gravity".)

Entropy falls under the umbrella of Noether's conservation theorem because the electromagnetic constant "c" gauges both the entropy drive and the metric symmetry of free energy, and when gravity conserves one it conserves the other by default. This dual role of gravity has always been the most mystifying of its attributes, but it originates in the dual role of c and the gravitational conservation of light's "non-local" distributional symmetry via time and the "location" charge, as required by Noether's theorem. The gravitational conversion of bound to free energy in stars, quasars, and by Hawking's "quantum radiance" of black holes fulfills the conservation role of gravitation with respect to both light's entropy drive and "non-local" symmetric energy state. In such conversions we see the intrinsic motion of time, acting through gravity, also driving toward symmetry conservation. Time, whether in its implicit form as the cause of light's intrinsic motion ("frequency"), or in its explicit form as matter's historical entropy drive, or as the active principle of gravitation's "location" charge, is the great agent of entropy and physical "prime mover" of change in the Cosmos. (See: "The Double Conservation Role of Gravity" and "A Rationale for Gravitation".)

Black Holes

So long as we consider only the combined form of spatio-temporal entropy, and restrict our analysis to relative descriptions of local, incomplete systems, we don't find a firm basis for entropy's conservation: spatio-temporal entropy may equal zero (at "equilibrium" or "absolute zero"), or even be reversed (by "work"). Stasis or reversal is impossible for the pure entropic forms in complete system descriptions: light and time are always moving forward, creating space and/or history, or being converted into one another. The black hole is an apparent exception to this rule, but only because gravitation takes over the protective role of the "infinite" velocities of c and T. In the black hole, gravitation accelerates spacetime to velocity c, stopping both clocks and light, sealing the borders of the spacetime metric (as in the "event horizon" and central "singularity") against leaks or intrusions by "wormholes". In the black hole, gravitation is the only remaining form of primordial entropy drive, so change can only proceed via the gravitational force. As Hawking has shown, however, even black holes actively convert gravitational entropy to spatial entropy, eventually evaporating the entire asymmetric mass of the hole to light, via the mechanism of "quantum radiance", operating just at the boundary between the gravitational and electromagnetic domains, in complete satisfaction of Noether's Theorem of symmetry conservation. Entropy is conserved and always increases, in one form or another, in complete system descriptions.

The connection between entropy and symmetry is not difficult to see: at any given temperature,

entropy is an expression of the symmetry (randomness) of energy distribution, which is completely realized only by the "non-local" character of light. This is why both entropy and symmetry can be driven/gauged with the same universal electromagnetic constant "c", and why both can be conserved by the same gravitational conversion of mass to light. The conservation of the symmetry of entropy as well as the symmetry of energy drives the evaporation of black holes via Hawking's "quantum radiance", surely the ultimate expression of the connection between symmetry and entropy, realized via the gravitational enforcement of Noether's theorem. In the end, even the symmetry of entropy is conserved: temporal entropy, being one-way, has less symmetry than spatial entropy, which is "all-ways".

Black holes, and the Bekenstein-Hawking theorem relating the surface area of the "event horizon" of a black hole to the entropy of the hole, constitute the physical and theoretical demonstration of the gravitational conversion of space and the drive of spatial entropy, to time and the drive of historical entropy. The event horizon of a black hole is a time surface, where time stands still because it is being replaced by the gravitational flow of space as fast as it moves into history (g = c). Seconds are stretched out to infinity, so co-varying space must completely vanish. Clocks stop and meter sticks shrink to nothing, the same metric condition established by "velocity c" in the electromagnetic metric - but in the black hole, this inertial state is established by gravity as the temporal metric completely overtakes the spatial metric, including all its conservation functions.

Just as we can envision the mass of a rock as an asymmetric expression of light's energy transformed to matter and brought to rest, so we can envision the surface area of a black hole as an asymmetric expression of light's entropy transformed to time and brought to rest. The surface area of a black hole is a "rock" formed of time, light's transformed and conserved entropy. As for the symmetric spatial form of light's expansive entropy drive or intrinsic motion, this is also visible (in large telescopes) as the cosmological "redshift" of distant galaxies and the expanding universe.

The black hole is the limit of gravitational strength, the end-point of temporal entropy, where all the spatial entropy drive of light has been converted to the historical entropy drive of time - the complete triumph of the gravitational temporal metric over the electromagnetic spatial metric, and of the forces of matter and darkness over the forces of space and light. But can the pendulum swing back? Even in this ultimate physical dungeon, there glimmers a ray of hope, for Noether's Theorem reminds us that symmetry must be conserved, even the symmetry of entropy, and that the all-way spatial entropy drive of light has greater symmetry than the one-way historical entropy drive of matter. Therefore, if Noether's Theorem is to be strictly observed, there must be a pathway or mechanism by which light can escape from the black hole prison, and indeed we find Hawking's "quantum radiance" of black holes demonstrating just this point. The great significance of Hawking's discovery is precisely that it proves the strict observance of Noether's Theorem, and tells us the ultimate conservation role and goal of both time and gravitation - the complete conversion of bound to free electromagnetic energy in the service of symmetry conservation.

The Causal Significance of the Connection Between Time and Gravitation

The physical connection between entropy and symmetry through the electromagnetic constant c (the gauge of light's intrinsic motion and expansive, "non-local" free energy) results in the conservation connection between temporal-historical entropy, symmetry, and gravitation. Gravity conserves both

light's entropy drive and light's non-local symmetric energy state via the "location" charge (whose active principle is time), through the conversion of bound to free energy in stars, quasars, and via Hawking's "quantum radiance" of black holes. (See: "The Tetrahedron Model".)

We might think that gravitation is too universal and important a force to be connected to entropy, even though this connection runs through the universal symmetry conservation principle announced in Noether's Theorem. Perhaps this is because we are used to thinking of (spatio-temporal) entropy as a matter of small importance in our daily lives, a matter of "waste heat" and disorder, whereas in physical fact the primordial drives of entropy are forces of the utmost universality and consequence. We must remember that entropy drives the spatial expansion of the Universe (the intrinsic motion of light) and the temporal expansion of history (the intrinsic motion of time). Gravity is producing the time dimension (entropy drive) of matter; the dimension of time and history is just as important to the material Cosmos as space is to the Universe of light. Finally, gravity produces spacetime, the joint dimensional entropy/conservation domain of free and bound forms of electromagnetic energy. There is nothing trivial about entropy in any of its forms. Entropy creates the dimensions of spacetime and allows us to use and transform energy.

There is furthermore the fundamental issue of temporal causality (law of cause and effect). The historic domain created by time and gravity (historic spacetime) contains all the causal linkages that lead up to, define, maintain, and uphold the "Universal Present Moment" of the material universe. Without the durable reality of the historic past, the effect of this causal matrix, which culminates in the present moment, would cease to manifest. My present life is connected by an unbroken causal chain (actually, a very robust expanding matrix or interconnected web) to the moment of my birth; if this matrix were broken, my present life and experience would cease to exist. Today exists because yesterday remains real. And by extension, my present life depends absolutely on the unbroken causal matrix of "yesterdays" that stretches back to the origin of the Universe in the Big Bang. All material events in the Cosmos are necessarily connected by a causal web from that primal initiating moment forward. This thoroughgoing connectivity is the essence of the meaning of the word "Universe". We can actually see this connection through our great telescopes in the images in spacetime of galaxies as they existed billions of years ago - their history affects us still, and in fact is still there (in part) for us to see (see: A Spacetime Map of the Universe). Our past is part of some other observer's "present moment", and vice versa. The homogeneity of the "cosmic microwave background" (to within a few parts in a hundred thousand), is the physical evidence for the thoroughgoing connectivity of the Universe from its very inception to the present day.

The significance of temporal entropy, time, and the historic domain of spacetime is that it establishes and maintains the causal, historic connectivity of the material Universe, upholding the reality of the Universal Present Moment. Light is connected by space; matter is connected by history; all are connected by gravity. This is the other (non-mechanical) rationale for associating temporal/historical entropy with a universal, unquenchable, and inescapable force such as gravitation. We are all immortal in the domain of historic spacetime.

Why Are There Three Spatial Dimensions?
(added Aug., 2013)

Fundamentally, the dimensionality of spacetime is a matter of energy conservation: three dimensions

are sufficient to establish an entropic domain in which the basic thermodynamic requirements necessary to conserve the energy of free forms of electromagnetic energy (light, EM radiation, etc.) are present; likewise, four dimensions are necessary to meet the conservation requirements of bound forms of electromagnetic energy (mass/matter).

Light is a 2-D transverse wave, with no time dimension and no space dimension in the direction of motion (clocks stop and meter sticks shrink to nothing at velocity c - as per Einstein). Light requires two dimensions to accommodate its alternating electric and magnetic fields, which induce each other at right angles. The energy of light is encoded in its frequency ($E = hv$) with its implied (but suppressed) time dimension. The intrinsic motion of light ("velocity c") "sweeps out" a third spatial dimension, creating, expanding, and cooling a 3-D spatial volume. The energy component of light is therefore 2-dimensional, while the entropy component corresponds to the 3rd spatial dimension. The entropy "drive" of light (free electromagnetic radiation) is the "intrinsic motion" of light, as gauged by the universal electromagnetic constant "c".

We see that three dimensions are sufficient for 2-D light to establish an entropy domain for its own conservation needs, and therefore light has no need to explore additional dimensional possibilities. Similarly, in the case of 3-D bound energy forms of electromagnetic energy (massive atomic "solids"), one further dimension (time) must be added to establish the entropy domain for matter (history), in which the "intrinsic motion" of time produces aging and decay (since atoms have no spatial form of intrinsic motion they must resort to time - which also suggests that the 3rd spatial dimension is the only possible higher-dimensional entropic option for light - if it is to remain in its free form). Gravity combines these two electromagnetic entropy domains into our familiar spacetime, the composite entropy domain of our universe of free and bound forms of electromagnetic energy. (See: "The Conversion of Space to Time" .)

In the "black hole", the electromagnetic metric of light and space (as gauged by the universal electromagnetic constant "c") is completely overwhelmed and replaced by the gravitational metric of matter and time (as gauged by the universal gravitational constant "G"). The energy of the black hole is encoded in its mass ($hv = mcc$), while the entropy is encoded in the two-dimensional "event horizon" (as per Bekenstein and Hawking - see: *Scientific American* Aug. 2003 pp. 58 - 65.) The entropy drive of matter and the black hole is the "intrinsic motion" of matter's time dimension, which creates the spatial flow of matter's gravitational field. *A gravitational field is the spatial consequence of the intrinsic motion of time*. The expansion of the black hole's "event horizon" is required (when energy is added to the hole) since the gravitational intensity and material density of the hole is already at a maximum ($g = c$); therefore the only way to increase the gravitational flow (which is necessary to increase the temporal entropy encoding for the added energy) is to increase the *size* of the gravitating mass, in other words, increase the boundary or surface area of the event horizon, which is the only part of the hole in active/actual contact with the outside spatial universe. If the black hole has a 3-dimensional "volume" at all, it is permanently hidden behind the event horizon, which is in fact a temporal entropy surface (see: "A Description of Gravity"). Hence the extreme temporal/gravitational /material metric suppresses space just as the extreme spatial/electromagnetic/light metric suppresses time.

Information is encoded in our ordinary universe in all four dimensions. Information requires the one-way 4th dimension (time) for its entropy drive and for its historical conservation domain, due to

the causal characteristic of information. Because the black hole either destroys, suppresses, or hides both the third and 4th dimensions, (time stands still at the event horizon and meter sticks shrink to nothing), the black hole contains almost no information, or as John Wheeler says: "A black hole has no hair". Information may live forever in the historical domain, but not in the black hole. Hawking should have stuck to his guns. (See: Leonard Susskind: "*The Black Hole War*"; Back Bay Books, Little, Brown and Co., 2008.)

The energy and entropy of information are encoded in the black hole's mass and the surface area of its event horizon. The causal component of information ceases to form new linkages upon entering the black hole and inside the event horizon distinguishable atoms are converted to "anonymous" photons. Causal linkages created by information outside the black hole, however, continue to propagate forever in historic spacetime. Entangled elements swallowed by the black hole are moot, since they remain hidden forever, suspended or "frozen" in time at the event horizon.

Information is one-way (asymmetric) due to causality, as well as due to the absence of antimatter ("anti-information");
Gravity is one-way and asymmetric;
Time is one-way and asymmetric;
Entropy is one-way and asymmetric;
Matter is asymmetric - due to its time dimension, gravitational field, lack of intrinsic motion, mass, and lack of an antimatter complement.

The black hole is the extreme case of the gravitational metric, as gauged by the universal gravitational constant "G". The black hole is the ultimate contrast to a universe of light with no matter at all, the extreme case of the electromagnetic metric, as gauged by the universal electromagnetic constant "c". In the light universe, all forms of energy move at velocity "c', time does not exist, nor does space (in the direction of a photon's motion). In the black hole also, all forms of energy move at velocity c, and space and time are absent. In this comparison, we see "velocity c" acting in both cases as the "gauge" of a symmetric energy state - specifically, a state of non-locality either outside or inside the black hole. In the light universe, photons and their energy content are distributed equitably everywhere, simultaneously - since there is no time parameter and no distance parameter (clocks stop and meter sticks shrink to nothing in the direction of motion at "velocity c"). This same "non-local" symmetric state with regard to the distribution of energy is achieved by the black hole *within* the boundary of its "event horizon" - again because all forms of energy move at velocity c, time has stopped and space has vanished, due to the action of a gravitational field whose strength is locally equivalent to the electromagnetic constant "c" (g = c). Clocks stop and meter sticks shrink to nothing at the "event horizon" of a black hole.

This discussion suggests that the conservation role of gravity is to pay the "location" symmetry debt of matter. The "location" symmetry debt/charge arises in consideration of the spatially undistributed (hence asymmetric) local concentration of immobile bound energy (matter), VS the spatially symmetric "non-local" distribution of light's energy (due to light's intrinsic motion "c"). Because matter is originally formed from light (bound electromagnetic energy is originally formed from free electromagnetic energy), matter carries a gravitational "location" charge, among other symmetry debts

in the form of charges and spin, due to matter's formation from all-symmetric light. (See: "Symmetry Principles of the Unified Field Theory".) The gravitational "location" charge is unique in that it represents an entropy debt as well as a symmetry debt. Because the intrinsic motion of light is both the entropy drive of light and the cause of light's non-local distributional symmetry, the gravitational "location" charge must conserve both functions if it conserves either one. (See: "The Double Conservation Role of Gravitation".) Gravity pays matter's "location" symmetry debt by creating black holes, in which "Hawking Radiation" converts (eventually) the entire bound energy (mass) of the black hole back to free energy (light).

Along the gravitational pathway leading to the creation of black holes, bound energy is also converted to free energy via the nucleosynthetic pathway of stars, and by the even more efficient conversion of gravitational energy and mass to light in other astrophysical processes such as supernovas and quasars. But once the black hole condition is reached, conversions of bound to free energy (in any appreciable quantity) essentially stop (so far as we know), if only because gravity prevents the escape of any light produced by such processes, should any occur. In the event horizon, gravity creates a temporal metric for matter which is the symmetric equivalent of the spatial metric of light - a metric in which all forms of energy move with intrinsic motion c. What happens in the interior of the black hole is moot, since we can never know. I suspect, however, that proton decay occurs at the singularity, and hence the black hole is filled only with light - another way in which the gravitational "location" symmetry debt is paid, also solving the problem of the infinite compressibility of matter. But nothing else matters once the event horizon is formed (at g = c); a symmetric temporal metric has been constructed in which all energy forms travel at c, and it would appear that no further conservation concerns need be addressed. But is this really the final word?

What then of "Hawking Radiation"? We note, of course, that Hawking radiation is pitifully small for any large hole, and tellingly, it gets smaller as the hole grows larger, not an encouraging sign for the cause of symmetry conservation at least via this route, since the natural tendency of the black hole is to forever increase in size, which means this symmetry conservation pathway is asymptotically suppressed in the natural course of events. However, if the interior of the black hole is indeed filled only with light, then some photons may escape the event horizon by quantum mechanical "tunneling", and this process might *increase* with the size of the hole, counteracting the decrease in Hawking radiation. Whatever the case, the amount of time available for this process (in a universe that does not collapse) is essentially unlimited (assuming that other, unknown cosmological processes do not intervene), so in the end the hole will completely evaporate its mass to light: bound, asymmetric electromagnetic energy returns to free, symmetric electromagnetic energy. One rationale for this scenario is that the temporal entropic metric of the black hole event horizon is less symmetric (being one-way) than the "all-way" spatial entropic metric of light, driving the eventual and final conversion of mass to light in complete satisfaction of Noether's Theorem. Nevertheless, the time required for this conversion to go to completion is so immense that it suggests Natural Law is in fact rather comfortable with this arrangement - the temporal metric of the black hole is stable, leaving little to be desired either inside or outside the event horizon in terms of conservation issues. This is another reason for suspecting that the interior of the black hole is filled with nothing but light, rather like a superconducting medium in which photons have become heavy.

All this notwithstanding, a major conservation issue remains unresolved, as attested by the continuing

presence in the surrounding universe of the black hole's powerful gravitational field, even after the event horizon has formed. So long as this field is present, the symmetry debt it encodes and represents remains unpaid. One reason that gravity keeps working even after the formation of the event horizon is that matter's entropy debt must keep being paid until matter's symmetry debt is completely paid, and as far as the outside universe is concerned, the black hole still represents a grossly asymmetric concentration of undistributed, immobile mass-energy, a severe affront to symmetry conservation in terms of the equitable dispersion of energy throughout space - as was originally the case for the light from which the black hole's matter was produced. The gravitational entropy debt of matter can be thought of as an "interest" payment on matter's symmetry debt - just as on planet Earth, the interest has to be paid until the symmetry debt is retired. But the Earth's gravitational field is too weak to convert mass to light, so it never "pays down" the principle on its symmetry debt - that is, despite the continuous working of Earth's gravitational field, it never gets weaker because it never converts any of Earth's mass to light. In our Sun, however, we see gravity actually "paying down" the symmetry debt of the Sun's mass by converting some of the Sun's bound energy to light, and hence reducing the Sun's total mass and its associated gravitational field. Gravity will vanish completely when its symmetry debt is well and truly paid, like any other charge (see: "Does Light Produce a Gravitational Field?"). So the black hole's gravitational field keeps working until the mass energy of the hole - whose entropy is represented by the surface area of the event horizon - completely evaporates away.

Since it is the surface area of the event horizon which is in contact with the outside universe, it is the surface area which generates the gravitational field. Hence the connection between time, gravity, and entropy is especially evident in this example. *A gravitational field is the spatial consequence of the intrinsic motion of time* (see: "The Conversion of Space to Time").

Further Readings:

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Links:

Unified Field Theory

Section I: Introduction to Unification
Symmetry Principles of the Unified Field Theory (a "Theory of Everything") - Part I

Gravitation

Entropy