

# Spatial vs Temporal Entropy: Part I

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## Abstract

The intrinsic motion of light is the entropy drive of free electromagnetic energy, creating, expanding, and cooling space. The intrinsic motion of time is the entropy drive of bound electromagnetic energy, creating, expanding, and diluting history. The intrinsic motion of gravity converts space to time (and vice-versa), creating spacetime, the joint dimensional and entropic conservation domain of free and bound energy.

## Introduction

Unless the context indicates otherwise, when I refer to "entropy" in these papers (especially in such phrases as "space and spatial entropy" or "time and temporal 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 "gauged" or regulated by "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 of bound to free energy. (See: "[The Tetrahedron Model](#)".)

## PartI: 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 - actually visible through our great telescopes as the "red shift" of distant galaxies).

2) Secondary or 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 as "gauged" or regulated by velocity c or "velocity T". 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 entropy drives. Space is ultimately related to the wavelength of light, and time to the frequency of light, such that frequency multiplied by wavelength = c.

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, 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 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 "velocity G". Gravitation is the conversion force between the primordial forms 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, derived from the "global" entropy of light (by the gravitational annihilation of space and the extraction of a temporal residue). The action of gravitation converts a global metric of space, light, and absolute motion gauged by "c", to a local metric of history, matter, and relative motion gauged by "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 Relativity). Because time and space are covarying parameters, energy conservation is accomplished despite the variable and relative motions of matter. 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). (See: "[Global vs Local Gauge Symmetry and Gravitation](#)".)

4) Spatio-temporal entropy, a tertiary form of combined entropy ("ordinary" entropy), resulting from the mixture of the primary, secondary, and gravitational forms (generally producing matter in 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" (dQ) divided by absolute temperature (T):  $dS = dQ/T$  (the entropy associated with molecular motion and kinetic energy);

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 of a probability expression. 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 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. (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 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 machine creating energy - a clear 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 time 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 matter to light. The intrinsic motions  $c$ ,  $T$ , and  $G$  are all physical expressions of entropy embedded in their energy forms.

It is because of their conservation functions as entropy drives that both the intrinsic motion 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.

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 of 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, gauged by "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 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 ( $S$ ) to time and the drive of historic entropy ( $T$ ) can be represented symbolically by a "concept equation" as:

$$\begin{aligned} -Gm(S) &= (T)m \\ -Gm(S) - (T)m &= 0 \end{aligned}$$

I enclose ( $S$ ) and ( $T$ ) in parentheses to indicate they are something more than simple quantities (the primordial entropy drives or intrinsic motions of light and time).

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 to light, as in stars, the 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](#)

## **Primordial Entropy Drives of Light, Time, and Gravity**

The primordial entropy drive of bound energy (matter) is the intrinsic motion of time, gauged by "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 annihilation of space and the extraction of a temporal residue, converting implicit to explicit time). Among its 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 meaning and can fulfill its deferred preservation 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 to the tangential connection (experienced by us as the transient "present moment") between matter and its historical conservation domain (historic spacetime). 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 both the energy and charge 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 "hot" free energy conservation system of spatial entropy involving immediate raw energy conservation through spatial expansion and cooling at "velocity c", to a "cold" bound energy conservation system of temporal entropy involving time-deferred charge conservation and the aging and dilution of history rather than of bound energy forms (such as atomic mass and charge), the Universe finds a method of releasing its energy slowly, allowing itself time to do the work of evolving life, consciousness, intelligence, and self-awareness.

## **Part II: Spatial, Temporal, and Spatio-Temporal 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 drives of free energy entropy, bound energy entropy, 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 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, as gauged by "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 relative motions 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, and aging 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 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 conversion of 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; and 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 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").

### **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). In the third law (which applies only to the combined form of spatio-temporal entropy), 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 entropy decay in stationary matter, are unaffected by low temperatures. A residual spatial entropy must exist if matter continues to simply occupy space; hence quantum mechanical energy fluctuations can never be completely quelled even at "absolute zero". Causality and velocity  $c$  also have no dependence on temperature; so 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 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 ( $E = mc^2$ ), 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 specific 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 thermodynamic entropy representations of Carnot and Clausius. The specific 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 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 forms of spatial and historical entropy - (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, as gauged by "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 is both the "non-local" symmetry gauge and the entropy drive of free energy and its dimensional 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. 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 light's entropic role and light's function as the gauge of spacetime's metric symmetry, which must operate regardless of the size or expansion rate of the Cosmos. 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 matter's undistributed, "local", energy concentration - "mass") 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  $c$  is both the entropy drive and the symmetry gauge 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 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. (See: "[The Double Conservation Role of Gravity](#)".)

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 clocks, sealing the borders of the spacetime metric (as in the "event horizon" and central "singularity") against leaks or intrusions by "wormholes". As Hawking has shown, however, even black holes actively convert temporal to spatial entropy, evaporating the entire asymmetric mass and temporal entropy of the hole to symmetric free energy, via the mechanism of "quantum radiance". 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 constant  $c$ , and why both can be conserved by the same gravitational constant  $G$ . 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 ( $g = c$ ). 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 light's 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.

### **The Causal Significance of the Connection Between Time (Temporal Entropy) and Gravitation**

The physical connection between entropy and symmetry through the electromagnetic constant  $c$  (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). (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. 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 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 time; all are connected by gravity. This is the other (non-mechanical) rationale for associating temporal entropy with a universal, unquenchable, and inescapable force such as gravitation. We are all immortal in the domain of historic spacetime.

### **Further Readings:**

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